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The N. E. L. A. Convention. WE publish elsewhere in our columns an account of the arrangements that have been made by the National Electric Light Association for its convention in Providence in February next. The executive committee is to be congratulated upon having gotten so early in the field and having laid out such an admirable programme of work to be done. In past years an effort has been made to arrange for a number of papers too great to be advantageously discussed at a single meeting. The result has been that much of the work has been hurried and numerous papers have been omitted. As it is now, with a well laid out programme three months ahead, it will be possible to have more detailed and exhaustive papers, and a discussion which will be of far more value to the members.

Latest Foreign News. With this issue of THE ELECTRICAL WORLD we begin the publication of a weekly cable dispatch from London giving the very latest English electrical news. A few brief notes reached us last week. We hope by this means to keep our readers fully informed as to the progress made in the electrical arts and industries on the other side of the water. We cannot well forget how much has been done by English electricians within the last few years, and no one who desires to keep thoroughly posted with regard to electrical matters can afford to pass by this important foreign work. Just now there is unwonted activity in the electrical traction field in England, and the appreciation which has been accorded to American methods is very gratifying. We believe that this new feature in THE ELECTRICAL WORLD will commend itself to our many friends, and that it will prove a valuable addition to our columns.

Electric Lighting on the Elevated. IT is stated by the managers of the Manhattan Elevated Railway system that the report which was recently going the rounds, that it had been definitely decided to put electric light into elevated trains, is unfounded. The Manhattan management undoubtedly has a keen interest in electrical developments, and will look with favor on any practicable plan for facilitating the operation of its system by electrical means; but the report, which has been freely published, seems to be somewhat premature. Eventually it will doubtless have to come, like the adoption of the electric locomotives on the elevated road; but the reform is not likely to be carried out immediately. In this connection it is much to be regretted that any attention has been paid by the public to a certain recent stupid and malicious attempt to discourage the use of the electric motor on elevated railroads. The statements made were far from creditable to the intelligence of the individual who saw fit to foist them upon an unoffending society.

Arc Light Carbons. WE give on another page a striking illustration of what can be done in the way of lengthening the life of arc light carbons. The device described is of an exceedingly simple character, consisting merely of a snugly-fitting fire clay collar resting just above the arc and maintained in a constant position relative to it. Its intention is to check that lateral waste of the carbons which gives them the familiar tapering point. How successful the apparatus is in this respect can be seen from a glance at the drawing of carbons used with and without the shield. Great claims are made for the economic value of the device, and however they may be substantiated in practice, it is apparent that the shape of the positive carbon is very greatly altered by the presence of the protecting jacket, and that the waste of material is confined almost entirely to the point. This tells its own story, and if by its use it is rendered practicable to burn a single carbon on all-night circuits with the present standard of size carbon, the new device must prove a useful addition to central station service.

Electricity at Cornell. IT gives us pleasure to present to our readers this week an account of the course in electrical engineering at Cornell University. Cornell was very early to appreciate the necessity for special technical education in electricity, and the course described has already won for itself a most enviable reputation in electrical education. The graduates have been more than usually successful in their professional work after leaving the university, and the amount of careful research that has been done in the electrical laboratory is well known to all of our professional readers. Of late especial attention has been paid to alternating current apparatus and methods, and some exceedingly interesting papers have been read before the Institute of Electrical Engineers and other scientific bodies, dealing with alternating current problems. With Professors Thurston, Nichols and Ryan as sponsors for the intellectual character of the school, we need have little fear that there will be any backsliding from the high position it has taken among institutions for the education of electrical engineers; and we sincerely trust that its prosperity will increase as rapidly in the next few years as in the past.

Lecture before the Electric Club. ON Thursday, Nov. 20, there will be given before the New York Electric Club a lecture that promises to be of rare interest. The subject will be The Artificial Light of the Future, and the lecturer will be Prof. E. L. Nichols, of Cornell University, who by his long experience in optical and electrical research work is peculiarly fitted to deal with this very important topic. He will discuss the present situation in electric lighting, and will bring before his audience not only a careful resumé of the most striking work that has been done, but will present the results of experiments hitherto unpublished. Electric lighting, successful as it is to-day, involves such a prodigious waste of energy that might be made useful, that it is extremely probable that the methods of utilizing electrical energy for illuminating purposes must undergo a radical change before any striking improvements can be made. On the road to progress there is little guidance as yet—only a few sign boards such as have been furnished by the experiments of Langley and others. To steal the firefly's magic art would be to raise a revolution in our commercial methods and to realize perhaps the brightest dream of the electrician.

A Pleasant Outlook. THE re-election of Mayor Grant, that doughty champion of hot subways and poor gas, is an unfortunate occurrence that all those interested in electrical progress can but look upon with evil forebodings. It was to have been desired that some intelligent and public spirited man of whatever party might fill the highest office of the metropolitan government, and administer his trust for the best interests of the people and the advancement of the common good. Since the accession of Mayor Grant to his official position the electrical industries of this city have been cramped and hampered in every way that seemed likely to bring them to a keen appreciation of the practical side of politics. He has bullied the Board of Electrical Control, insulted its expert, encouraged subway extortion and left the streets as dismal as they are dirty. And now he has taken a fresh lease of public life—paid for at the usual rates. It would be advisable, however, for him to pause before beginning anew his former course and contemplate the fate of certain other politicians who recently overstepped the bounds of public patience. The tidal wave that bore him back into office is too significant in its terrific outbreak of suppressed power to be forgotten in a day. The memory of it should be a warning not to carry municipal affairs with too high a hand.

Direct Coupled Dynamos. THE combined engine and dynamo has worked its way into a firm position in the electric lighting industry, and it is more than likely that the next decade will find its use even more familiar than at present. The exigencies of marine lighting gave a stimulus to the development of this particular type of machine, for in the contracted space usually allotted to the dynamos on ship board driving by belts is no easy matter. It has now been demonstrated that direct coupled machines can be so built as to compare favorably in point of economy with the ordinary arrangement of engine and dynamo. We give this week some interesting figures on tests of this class of machinery recently made in England. A commercial efficiency of 86 per cent. from the indicated horse power of the engine to electrical output on the line certainly leaves little to be desired, and it is worth noting that the particular machines tested were designed not for ship use but for the regular service of a central station. With the modern types of efficient machinery the early objections to direct coupling are fast disappearing, and particularly in cities, where floor space is very valuable, the arrangement is most desirable. It is to be hoped that some of our American makers will bring out tests of similar combined machines that will demonstrate that in this, as in most other modern developments of electricity, Yankee ingenuity is in the front rank. We have faith to believe that if 86 per cent. efficiency can be obtained on the other side of the Atlantic, we ought to expect 87 per cent. here. Who will be the first to reach it?

An Electric Underground Railroad. IN our London letter this week will be found an interesting account of the City and South London Railway, the opening of which was noticed in our issue of last week. It is in some respects the most important electric road as yet built, for it is the first deliberate attempt to operate what is really a suburban underground system by electricity. The results, after the line gets in full working order, will be full of interest to American engineers, since the time is now almost here when we shall have the electric motor in the place it deserves for suburban traffic. The electric locomotives of this railway are of about 100 h. p. The total length is about 10 feet, and one pair of driving wheels is used. A very interesting feature is the placing of the armature directly upon the shaft. This is a great advantage from the standpoint of economy, and, if the arrangements have been carried out with a proper degree of mechanical skill, some very instructive results may be anticipated. At present in our common street car service direct connection of this kind is not an accomplished fact, except in an experimental way, for the reason that no ordinary motor will run at a speed slow enough to permit of its being thus connected. On the large motors in London, however, the higher speed to be attained, and the great power of the motors, allows the direct connection to be used, and, as we have many times pointed out, the higher the speed and the greater the power of the electric locomotive to be built, the easier does the mechanical part of the problem become. We sincerely hope that the City and South London Railway will have nothing but success to report, and cannot but regret that American enterprise should not have come to the front in this electric traction on a large scale as well as in the—in some respects—more difficult problem of operating ordinary street cars. If the West End Railway in Boston carries out its elevated road plan as it is expected and hoped that it will, there will soon be an opportunity of comparing the work of English and American electrical engineers in extending the already wide field for electric traction.

Latest Foreign Electrical News.

(By Cable from our Regular Correspondent.)

LONDON, Nov. 10, 1890.—At a meeting of the Metropolitan Electrical Supply Company, Nov. 7, Sir John Pender reported on the work of the year, and stated that the number of lamps supplied had risen in that time from 15,000 to 40,000, being one-third of the total lights of London. Forty miles of mains had been laid and four stations completed, while a fifth is building for Paddington, and the company is doing well financially. Next Thursday, Nov. 13, Prof. Ayrton will read a paper before the Institution of Electrical Engineers on the chemistry of secondary cells, and afterward it will be discussed, together with the same author's Edinburgh paper on the "Working Efficiency of Secondary Batteries."

The accumulator cars which have been running for some months on the Bristol road line of the Birmingham tramway system are not meeting with the success at first hoped. There is much complaint of breakdowns, and the matter has been agitated so much that the directors of the Electric Construction Company who are responsible for the work are led to reply that while the cars were built to carry sufficient battery power to operate them on ordinary runs, with sufficient margin, the road on which they are now used is unfavorable by reason of a wooden pavement that throws the track out of line, and the supply of power is insufficient.

It is reported that the Edinburgh Exhibition which has been open since May, and has just closed, seems likely to result in financial loss.

Electrical Engineering at Cornell University.

Cornell University, at Ithaca, N. Y., owes its existence to the generosity of the United States government in setting apart 990,000 acres of land to be used by the authorities of the State of New York in establishing and maintaining a college "where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts," as well as to the magnificent benevolence of Ezra Cornell in giving upward of $500,000 to aid in its endowment. Its doors were first opened for the admission of students on the seventh of October, 1868, and from that time to the present the institution has had a rapid and vigorous growth until the number of students registered in the various departments for the last academic year was more than 1,300, and of these about one-half were engaged in technical studies.

The university campus, around which the dozen or fifteen great buildings of the university proper are grouped in a more or less perfect quadrangle, is situated on the brow of the high hill which overlooks the town of Ithaca, lying 400 feet below and less than a mile away, and affords a charming view of the picturesque Cayuga Lake, a beautiful sheet of water, stretching away to the northwest in full view for ten or twelve miles. The buildings in which the greater part of the technical instruction is given are located at the extreme northern end of the quadrangle, on the edge of Fall Creek gorge, from which water power is derived for driving a part of the machinery in the engineering laboratories and the mechanical workshops. This collection of technical schools, which give instruction in mechanical engineering and the mechanic arts, is known as Sibley College, and is but one, though very important, branch of the university proper. It is not our purpose at the present time to treat of the work done in all these schools, although it would be a pleasure to point out the excellent facilities possessed for imparting instruction and the high character of the work as carried on under the immediate and able direction of Dr. Thurston. We must confine our attention to a brief survey of the instruction in electrical engineering, the material equipment of the electrical laboratories and of the aims and purposes of the faculty of this department in conducting what is now the largest and best equipped school of electrical engineering in this country.

One of the very first among institutions of learning to offer instruction in electrical engineering was Cornell University, the course being established by Prof. W. A. Anthony, with the aid of President Andrew D. White and the practical support of the Board of Trustees of the university. In 1883 a four years' course was announced for the academic year of 1883–4; and what was regarded by many friends of the cause of technical education as a premature experiment was begun. The new work, which owed its inception in a great measure to the efforts of Prof. W. A. Anthony, remained in his charge up to the time when he resigned his position upon the university staff in 1887. The beginnings in this new department were very modest; the classes were small and the special equipment a very moderate one; but the growth of electrical interests within the college, like that of the larger electrical interests of the outside world, has been very rapid, and at the present time half of the students of Sibley College of Mechanical Engineering are making electricity their principal study.

It was recognized at the outset by those who had a hand in the organization of the new department that the education of young men who seek training in applied electricity needs to be, in many respects, identical with that of the student of mechanical engineering. This idea has been fully carried out, and the mechanical and electrical engineers at Cornell work side by side in draughting rooms, machine shops and laboratories throughout the four years of their college course. The requirements for admission in the two courses are the same, and for the first three years the curriculum is identical. The result is that at the end of his junior year it is still possible for the young engineer to revise his earlier and less mature plans as to the line of work which he desires to pursue, and to devote himself either to mechanical engineering pure and simple, or to the newer lines of study in practical electricity. In consequence of this dual arrangement of courses, students of electricity reap the advantage of all the more important features in the course of training prescribed for mechanical engineers, while students of mechanical engineering, in their turn, obtain a much broader knowledge of practical electricity than has usually been deemed essential in their profession.

Looking briefly at the work which the student of electrical engineering at Cornell is required to do during the four years of his undergraduate course, we find that it consists of several distinct lines which are followed simultaneously to certain definite ends. These are, (1) Mathematics, leading up to the study of applied mechanics and allied branches; (2) Physics (including chemistry), leading to the detail study of applied electricity; (3) Mechanical Drawing, leading to work in electrical machine design and construction; and (4) Shopwork, running, like the other three lines through the four years, and giving the student, in addition to mere manual skill and experience in workshop routine, that precise and definite knowledge of the proper methods of working up the raw materials of construction which is so necessary to the engineer.

In pure mathematics the courses prescribed comprise a year of solid and projective geometry, algebra and trigonometry, and a year of analytic geometry and calculus. These are followed in the third year by the study of the mechanics of engineering, and may be supplemented in the fourth year of the course by a further study of pure or applied mathematics to any extent which the student may desire. A course in molecular dynamics, based on Sir Wm. Thomson's Baltimore lectures, is open to such students as may be fitted to profit by it, and is under the direction of Mr. Hathaway, who reported the lectures, and, with the aid of Sir Wm. Thomson, prepared them for the press. An optional course in the mathematical theory of electricity and magnetism is also offered.

In the second year of the course is begun the study of physics and chemistry, experimental lectures being given during the entire year upon mechanics and heat, electricity and magnetism, and sound and light. Lectures upon chemistry for two-thirds of the year are supplemented by work in the chemical laboratory for the remaining one-third, and this work is also extended over the first third of the following year. In the third year the study of physics is carried out by laboratory practice in the use of electrical and other physical instruments for the verification of physical formulæ, with a view to the attainment of some knowledge of the simpler methods of physical manipulation. In electricity this work consists of the adjustment and calibration of galvanometers, of the verification of the principles upon which the measurements of current, electromotive force and resistance are based, the use of the electrometer, and the performance of such other experiments as are thought to offer the best preparation for the more advanced work of the following year.

Four years in the drawing-rooms also aid in the improvement of the student in all that is essential to his professional success. No accomplishment is more universally demanded than the making of a good drawing, and this line of work is continuous throughout the course, beginning with free-hand work, machine sketching and descriptive geometry, and ending with machine designing and the planning of dynamos, engines, boilers and complete plants.

Parallel with these distinctive courses of instruction are carried on the characteristic work of the engineer in the shop and the mechanical laboratory. The student gives a fair proportion of his time, from beginning to end, to the practice of shop work; the first year in the woodworking department, the next in blacksmith shop and foundry; and the latter part of his course takes him into the machine shop, where he constructs, from his own designs, special apparatus for original research, or machinery of importance for other purposes.

What may be called the professional work of the course is chiefly in the senior year. It consists indeed in the final application of the lines of study, which have just been indicated. The student comes to it strengthened by three years of preparation in mathematics, draughting, shopwork, physics and chemistry, and the modern languages. In the physical laboratory, where he is already at home, he now gets extended knowledge of electrical measurements and makes a detailed study of dynamos and motors. In the draughting room he applies his three years' training to the many interesting problems in the designing of electrical machines and in station construction. Finally, in company with his fellow, the senior mechanical engineer, he studies the steam engine.

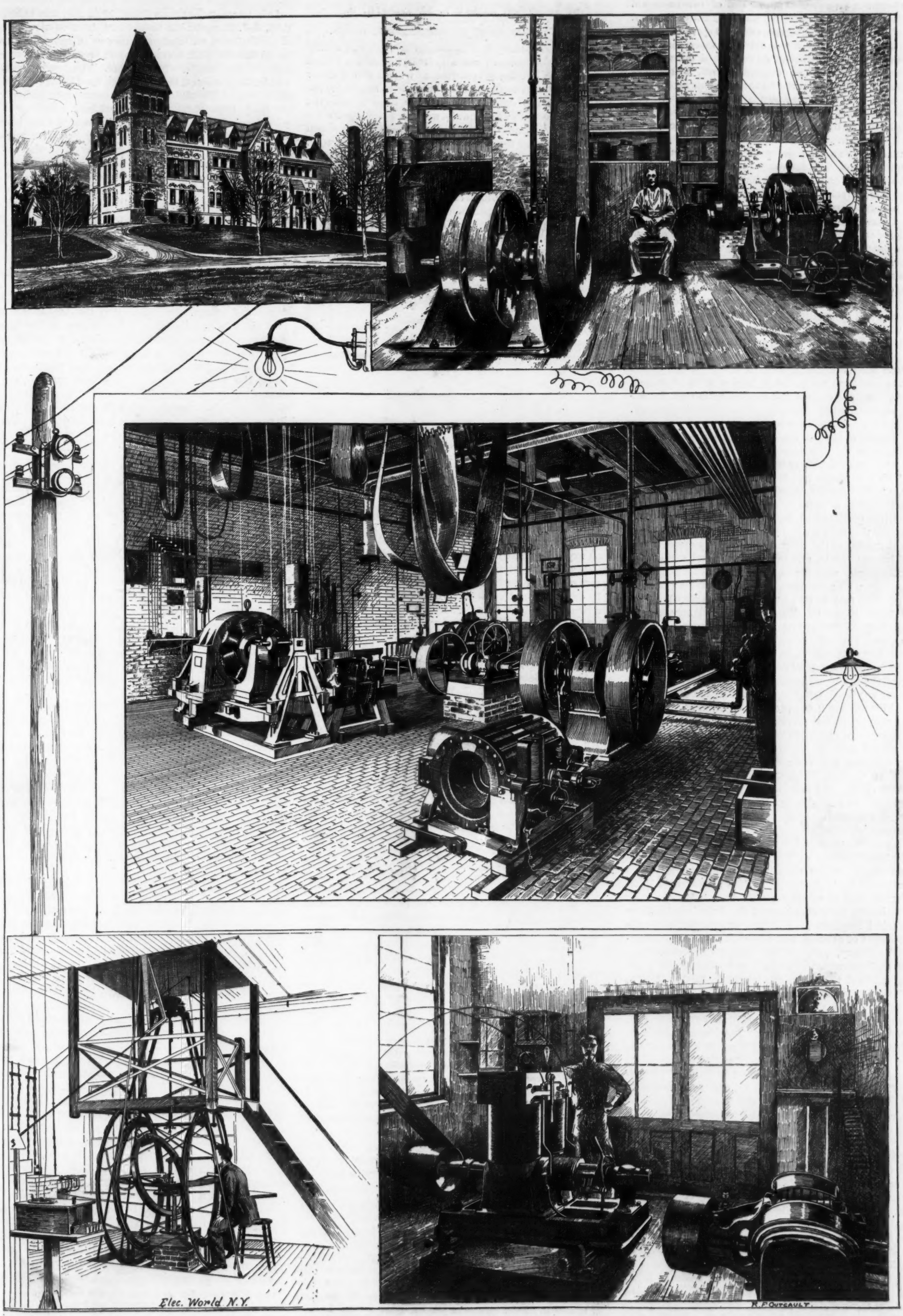
The crowning work of the course, however, upon which great stress is laid, and to which much of the time of the senior year is devoted, is the thesis. The subject may be one involving questions of technical detail, or it may be one demanding original investigation. To the young electrician the idea of research is always an attractive one, and in the field of his activity he has no difficulty in finding unsolved problems worthy of his attention. Already in the few years since the establishment of the course in electrical engineering, many useful investigations have been completed as thesis work, and quite a number of these have found places in the columns of the electrical journals of this country and Europe. Among the papers detailing the results of laboratory work at Cornell, which have been most widely published, may be mentioned "The Efficiency of the Arc Lamp," "The Personal Error in Photometry," "The Efficiency of Methods of Artificial Illumination," "The Relation between the Cross-section of the Iron in Armature and Field of the Gramme Dynamo," "On the Differing Temperature Co-efficients of the Different Coils of a Fine Rheostat," "Notes on the Performance of Some Dynamos," "Dynamo Regulation by Means of a Third Brush," "A Swinging Arm Galvanometer," "Some Electrical Properties and Uses of Carbon," "On Compensated Resistance Standards," "On the Change from Negative to Positive in the Temperature Co-efficients of Some Carbon Filaments," "The Spiral Coil Voltameter," "Transformers," "Life and Efficiency of Arc Light Carbons," "On a New Photometer," "Some Experiments Upon Alternating Current Apparatus," "Efficiency of the Transformer," and the "Investigation of the Stanley Alternate Current Arc Dynamo."

A considerable percentage of those who graduate each year in electrical engineering find it to their advantage to remain at the university one or two years longer, devoting their attention to the study of special problems. The careers of those who have taken this additional time for advanced study of the subject have furnished the best possible evidence of the value of such a course. They have almost without exception made much more rapid progress in their profession than those who have entered practical life immediately after graduation.

The laboratory building which is known as Franklin Hall, and which until the present year has been occupied conjointly by the departments of physics and of chemistry, is now entirely given up to the study of the various branches of physics. This building, which is shown at the top of the opposite page, was opened for occupancy in September, 1883. It is of red sandstone, its dimensions being about 60 ×140 feet, and is three stories in height above the basement. Casts and medallions of distinguished scientists serve to render the exterior of the building more ornamental. The basement and a part of the first floor are devoted to laboratories for the experimental study of the subject of heat. On the first floor is also the lecture room of the professor of physics, which is arranged in amphitheatre style, with a seating capacity of 154. The arrangements for experimental lectures in this room are very complete. Gas, water, steam, oxygen, hydrogen, compressed air, blast and vacuum cocks are at the lecturer's hand. Dynamo and battery currents of any desired character are readily available through the lecture room switchboard. A small turbine for furnishing power and lanterns provided with lime and electric lights add to the completeness of the equipment. Adjoining the lecture room are the apparatus rooms, stocked with an excellent equipment, valued at more than $40,000, for the experimental demonstration of a great variety of physical phenomena. On the same floor and adjoining the office of the professor of physics is a photometer room, painted black throughout and provided with a Bunsen photometer for measuring the candle power of both arc and incandescent light. The laboratories for the junior work are on the upper floors of the building, where a complete set of rooms, comprising a general laboratory, balance room, dark rooms for photometry and spectroscopy, galvanometer rooms and a laboratory for work in heat are wholly given up to the work of the junior year. In connection with these is also a reading room, library and an instructor's office.

At the rear of Franklin Hall is a fireproof one-story building of brick, formerly occupied by the department of organic chemistry as a laboratory, but now used as a galvanometer room. This building is 37 × 100 feet, and in it are arranged to the best advantage a part of the university's equipment of galvanometers and some of the other electrical measuring instruments. Of galvanometers alone the department possesses about 60, costing something more than $6,000. The smaller rooms adjoining the galvanometer room will be used for storage batteries and work with the voltameter and electric meters. The storage battery plant aggregates 120 cells of the Julien, Gibson, Sorley, Brush and "accumulator" types.

The new dynamo room of the electrical department is located in that one of the Sibley College buildings which adjoins the physical laboratory described above. It has a floor space 40 × 70 feet, and contains, without doubt, as fine a collection of dynamos as can be found anywhere in the world. Among the machines in this dynamo laboratory may be mentioned six small Westinghouse dynamos, three Weston, six Edison, one Stanley alternator, three Thomson-Houston (different patterns), one Waterhouse, one Ball, one Mather, one Siemens & Halske, one Gramme, besides one Brush, one Tesla, and two Sprague motors, and a half dozen or more dynamos and motors constructed at the university by Mr. Fred. Fowler, the ingenious mechanician employed by the



VIEWS IN THE DEPARTMENT OF ELECTRICAL ENGINEERING OF SIBLEY COLLEGE, CORNELL UNIVERSITY.

department. A 35 h. p. "Ideal" engine constructed at the Sibley shops has been erected at one end of the room and this will re-enforce when necessary the water power obtained from Fall Creek gorge, or when a constant speed is wanted in the experimental work will drive the machinery independently of the water wheel. At one side of the room is a 200-terminal switchboard designed by Prof. Moler. The arrangement of the dynamos and their circuits is such that the machines may be all used simultaneously, that any one or all may be disconnected instantly, and that any one or all may be driven by either steam or water power or may be shifted if desired from one source of power to the other. All of the machinery and apparatus of this room is at the command of the student for experimental purposes. The view at the centre of our page of illustrations shows how some of these machines are utilized for testing experiments, a large alternator being here shown mounted upon a Brackett dynamometer cradle, and the Straight Line engine on the left being fitted with a Prony brake. The Thomson-Houston arc machine shown in the foreground is also used for experimental purposes.

In an adjoining room, one view of which is shown at the bottom of the page illustration, are placed all of the dynamos which are used in the regular lighting service of the campus and its buildings. Here are found a Westinghouse 650-light machine, a Stanley alternator, an Edison machine and a Weston. In the same room are placed two 30 h. p. Straight Line engines, one 25 h. p. Payne, a 75 h. p. compound Westinghouse, a 20 h. p. Westinghouse, and a 60 h. p. engine from the Lansing Engine Works, Lansing, Mich. All of these engines and dynamos are used by advanced students, when necessary, for experimental work.

Perhaps the most noteworthy single piece of apparatus which forms a part of the equipment of the electrical laboratories is the "mammoth" tangent galvanometer, which is shown at the lower left-hand side of our page of cuts. This instrument was constructed by Prof. W. A. Anthony in 1885 for the use of the department, and was fully described in a paper read by him before the American Institute of Electrical Engineers in May, 1886.* The circuits of the coils are so connected to the switchboard shown at the left of the instrument that any one coil may be used independently, any two or four in series, the large pair differentially with the smaller pair, or one large coil differentially with a small one. Currents ranging from 4 to 250 ampères may be measured with deflections of the needle from 25 to 60 degrees. This galvanometer is mounted in a building as free as possible from magnetic disturbance. The coil shown in the accompanying cut as removed from its suspension and tilted over to one side is provided for the purpose of determining the horizontal intensity of the earth's magnetism whenever the instrument is used for any work requiring great precision of measurement. This method is one proposed by Sir Wm. Thomson, and has proved of great service. The galvanometer switchboard being connected with that of the dynamo laboratory can be placed in the circuit of any one of the score or more of experimental and commercial machines, and a large rheostat of German silver wire with a capacity ranging from 2,200 ohms and 4 ampères to four-tenths of an ohm and 300 ampères may also be connected in circuit.

Through the efforts of an efficient corps of professors and instructors, all of these facilities are used to the best advantage. The electrical engineering course is under the immediate supervision of Prof. Edward L. Nichols, who has had charge of the department of physics since the resignation of Prof. Anthony, in 1887; Professors Ryan and Merritt, both of whom are well known through their contributions to the proceedings of the American Institute of Electrical Engineers, the American Association for the Advancement of Science and other societies, give instruction in the theory, practice and design of electrical machinery and apparatus; while Prof. Moler and Mr. Shepardson superintend the experimental work in the dynamo laboratory. The mechanical side of the electrical engineers' training is well cared for by a full faculty of instructors under the guidance of Dr. Robert H. Thurston, the director of Sibley College, who personally gives instruction in the theory and practice of the steam engine. A large library well supplied with a great variety of electrical books and sets of the most important periodicals in English, French and German, and furnished with all the publications of the British and United States patent offices, comprising several thousand volumes, is of great assistance to the student in original work of an historical nature. It may be said, perhaps, that the most distinctive feature of the school of electrical engineering at Cornell is the stress which is laid upon the importance of original investigation by the student himself. The result of the practical application of this idea is that the student, while he acquires a thorough knowledge of a great variety of phenomena that present themselves in the course of an investigation of any single subject, becomes at the same time possessed of higher ideals and higher aims in the study of the various branches of his chosen profession, each solution being sought out that it may aid in the understanding of a more intricate or more abstruse phenomenon. There is no member of the faculty of the Cornell school of electricity who has not already distinguished himself among his scientific colleagues by an original investigation of considerable importance or an ingenious invention of commercial value.

* See THE ELECTRICAL WORLD, May 29, 1886.

Electromagnetic Radiation.*

BY PROFESSOR ARTHUR L. KIMBALL, PH. D.

HOW TO OBTAIN SHORT ELECTROMAGNETIC WAVES.

When the electricity in a conductor is disturbed in any way it does not instantly come to rest, but surges to and fro, gradually coming to rest, just as when a tub of water is tilted the water oscillates from one side to the other, the motion dying out only gradually. The time it takes the water to surge backward and forward in a tub is perfectly definite, and depends on the shape and size of the vessel and the depth of the water. Just so in all conductors: when the electricity is disturbed it oscillates in a perfectly definite period, which depends on the shape and size of the conductor and the medium in which it is placed.

It will be found useful to compare the vibrations of the electricity on a conductor with the vibrations which a spring makes when set oscillating in a vessel of some viscous fluid such as molasses. The spring rapidly comes to rest under these circumstances for two reasons: first, the resistance of the fluid causes some of the energy to be lost

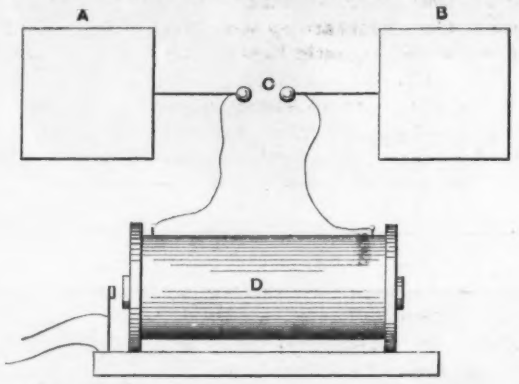


FIG. 5.—HERTZ' EARLY FORM OF VIBRATOR.

in heat, and secondly, part of the energy is sent out in waves in the fluid. As soon as all the original stock of energy is expended in this way the spring is at rest. So in a conductor the energy of the electrical oscillation is soon expended, partly in heating the conductor owing to its electrical resistance, and partly in electromagnetic waves which are sent out into the surrounding medium.

In determining the time of vibration of a spring there are two elements that enter, its *stiffness* and its inertia. That is, the stiffness of the spring tends to make it vibrate quickly, while its mass and the mass of the liquid which it drags with it in oscillating tend to retard the vibration. In the same way, in an electric system, there are two elements which determine the period of vibration, its capacity and its self-induction. Take the case of the discharge of a Leyden jar. When a jar is discharged the elastic force with which the charging is resisted is greater the *smaller* the capacity of the jar, so that a Leyden jar of small capacity may be compared with a stiff spring, and so the rapidity of the electrical vibration is increased by diminishing the capacity of the jar. In the discharge of the jar, as the electricity rushes from one coating to the other, it constitutes a *current*, and sets up a magnetic field around the conductor through which the discharge takes place; but it takes time to establish a magnetic field just as it takes time to set a heavy wheel rotating, and this constitutes a *drag* on the electricity, so to speak, and the greater the number of lines of magnetic force thus set up

FIG. 6.—HERTZ' RESONATOR.

the slower will be the rush of electricity, so that the greater the self-induction of the circuit in which the discharges takes place (the coefficient of self-induction of a circuit being the number of lines of force which unit current will set up when flowing in the given circuit) the longer will be the time of oscillation of the discharge.

An exact mathematical discussion shows that the time of vibration of an electrical charge in a conductor when the resistance is so small that it may be neglected is

$$T = 2\pi\sqrt{C\,L}$$

where C is the capacity of the system and L is its coefficient of self-induction.

To give an idea of how rapid these vibrations are the following cases given by Prof. Oliver Lodge are selected. A condenser of one *microfarad* capacity discharged through a good conducting coil, whose self-induction is one *quadrant*, gives a current alternating about 160 times per second.

A gallon Leyden jar (capacity about .008 microfarad) discharged through a stout wire suspended once around an ordinary sized room gives an alternating discharge of about one million alternations per second. A pint Leyden jar discharged with the ordinary discharging tongs gives some 15 millions of alternations per second, thus sending out electromagnetic waves about 15 or 20 yards in length. Prof. J. J. Thomson has shown how to calculate the time of oscillation of an electric charge on a sphere, and it is found that the ether waves sent out are about half as long again as the diameter of the sphere. Thus, on a sphere of two feet in diameter, the electricity would surge to and fro at the rate of 300 millions of vibrations per second, giving rise to electromagnetic waves a yard long.

Professor Lodge, in some very interesting experiments, was able, by using an enormous battery of Leyden jars and thus securing great capacity, and by also discharging through a circuit of large self-induction, to increase the time of oscillation, so that it was slow enough to give rise to a distinct musical note, each discharge giving a sound of a definite pitch. The whole subject of the discharge of the Leyden jar has, indeed, been discussed by him in a most interesting and instructive lecture which is printed as an appendix to his "Modern Views of Electricity."

The oscillatory character of the discharge of a Leyden jar seems to have been first noticed by Professor Joseph Henry as early as 1842. Since then the fact has been established beyond all doubt by the experiments of Feddersen and others. In order that the discharge may be periodic, it is essential that the resistance of the circuit is not too great. The effect of increasing the resistance of the circuit is to make the vibrations die out more rapidly, and also to slightly lengthen the period of vibration, until, when the resistance reaches a certain amount, the discharge ceases to be periodic and the redistribution of the electricity is accomplished without any oscillation, just as in case of a spring in a viscous fluid, by using a liquid which offers enough resistance the spring when displaced will simply move back to its original position, but without going beyond it and springing back.

THE EXPERIMENTAL STUDY OF ELECTROMAGNETIC WAVES.

It has been known for many years that these electrical oscillations existed, but it remained for Professor Hertz to show how the electrical waves given off from such a conductor might be detected and studied. The method of which he was the discoverer depends on what may be called *electrical resonance*. When a tuning fork is struck and held successively to the mouths of bottles of various sizes, it will be noticed that, while little or no effect will be observed in most cases, yet a bottle may be found of such a size and shape that it will strongly re-enforce and strengthen the tone of the tuning fork; this is the case when the air contained in the bottle has a natural time of vibration the same as that of the tuning fork. A more striking experiment is to take two tuning forks exactly alike, having the same pitch, and mounted on suitable resonance boxes, and, placing them at a distance apart of several feet, to sound one of them strongly. The other will be found to be set in vibration simply by the sound waves coming from the first, and will continue to sound after the first is stopped. The explanation is very simple; the first air impulse received by the distant fork starts it vibrating, the next comes after a complete vibration, and is, therefore, just at the right time to increase the motion, and so on, each impulse increasing the effect of those that came before, and in this way even so rigid a body as a tuning fork may be set vibrating by the feeble impulses received from the air waves, in the same way as a boy can ring a heavy bell by exactly timing his pulls on the rope to the natural swing of the bell.

It was discovered by Hertz that if two electrical conductors are taken of such sizes and shapes that the time of electrical oscillation in the one is the same as in the other, that when strong electrical vibrations are set up in one the other will also have an electric disturbance sympathetically excited. It is by making use of this fact of *electrical resonance* that Hertz was able to demonstrate the existence of electromagnetic waves and to measure wave lengths.

It will be well to examine briefly how some of the more important results have been demonstrated. Hertz' apparatus involved what we shall call the vibrator and the resonator. In his earlier experiments the vibrator consisted of two sheets of tin, A and B (Fig. 5), about a foot square, provided with knobs and separated by a small gap C. These plates were connected one with each pole of a powerful induction coil D. The resonator (Fig. 6) was simply a hoop of wire, in which there was left a gap, the terminals being made of little knobs, whose distance apart could be accurately adjusted by means of a micrometer screw.

When the induction coil was made to act, the plates A B were charged and discharged by sparks across the gap C.

Let us suppose a single rush of electricity from the induction coil has charged the plates A and B so that A is positive and B is negative; there will at once be a discharge across the gap C which will not stop when A and B are at the same potential, but the rush of electricity will continue, A becoming negative and B positive; just as a pendulum when let swing does not stop at the bottom, but swings up on the other side, then the electricity will rush back again making A again positive and B negative, and this backwards and forwards surging of the electricity keeps up until all the energy of the charge has been dissipated either as heat or in electrical waves which have been sent out. The time required for each vibration of the electricity was about one two-hundred-millionth of a second, and as the energy was pretty well exhausted after a dozen or so vibrations, it is clear that the whole thing would be over in

* Concluded from THE ELECTRICAL WORLD, Nov. 8, 1890.

much less than a millionth of a second, and the plates would be ready for a second charge; this action was repeated 100 or 200 times a second, depending on the frequency of the sparks given by the induction coil.

The resonator *E* was made of such a size and shape that the period of electrical vibrations in it might be the same as in the vibrator, and the adjustment was finally made by changing the sizes of the knobs until the best effect was obtained. The knobs at *E* were then carefully polished and adjusted so as to be barely not in contact with each other, so that when the electricity in the hoop was made to surge backwards and forwards by means of the waves sent out from the vibrator, the action was detected by the minute spark observed between the knobs at *E*.

The intensity of the effect could be estimated by separating the knobs of the resonator till the spark just ceased to pass, and noting the distance apart of the knobs as measured by the micrometer screw.

In a dark room Hertz was able to observe this resonance at distances as great as 40 or 50 feet from the vibrator.

One of the points examined was the reflection of these waves. Theory shows that a conductor should be a good reflector of electro-magnetic waves. Hertz constructed two parabolic reflectors of thin sheet metal, and, placing the vibrator in the focus of the one and the resonator in the focus of the other, was able to obtain very marked effects when the two were placed opposite each other, the spark being observed at much greater distances than without the reflectors. In this experiment the radiator or vibrator employed was different from the one already described, and gave much shorter waves; it consisted of two small tin cylinders, each terminating in a knob and separated by a small spark gap, each being connected to a pole of the induction coil. This arrangement gave waves less than two feet long and thus better suited for experiments in reflection than the longer waves given out by the other vibrator. Of course each vibrator has to have a resonator specially adjusted to it.

Hertz has also measured the refractory power of pitch for these waves by inserting between the two parabolic mirrors an immense prism of pitch: in this way the index of refraction of pitch was found to be 1.7, or, in other words, electromagnetic waves travel through air or a vacuum with 1.7 times the velocity with which they are propagated in pitch.

Again, it was found that a conducting screen, even of thin gold leaf, would completely cut off the effect upon the resonator when interposed between it and the vibrator, but that non-conductors did not produce this effect, the disturbance being readily communicated through a wooden partition or even a brick wall. This is entirely in accordance with theory, which shows that conductors should be opaque to these electromagnetic waves, while non-conductors should be transparent.

But how can it be established that these effects are really due to waves, and how can the wave lengths be measured? The characteristic phenomenon by which the existence of waves is recognized is *interference*. That is, two waves may come together in such a way that one shall exactly neutralize the effect of the other, or by slightly changing their relative *phases* they may re-enforce each other. In case of water waves, for example, if two sets of waves are coming from separate points, there will be certain points where the crests of the two sets of waves will arrive simultaneously; these will be points of great disturbance; there will be other points where the crests of one set of waves will arrive at the same instant as the troughs of the other sets of waves; these will be points of minimum distribution, for one set of waves will largely or entirely neutralize the effect of the other set. These are what are known as *interference* effects, and it is by these interference effects in case of light that it is known to be a wave motion, and that the wave lengths are measured. It at once became a point of peculiar interest to discover whether such effects could not be demonstrated in case of electromagnetic waves, and the discovery of these interference effects by Hertz established beyond all question the existence of electromagnetic waves.

In one experiment the vibrator sending out the waves was placed directly opposite and at a distance of 40 feet from a wall which had been covered with sheet metal and so was a good reflector. The reflected waves meeting those coming directly from the vibrator gave rise to interference, producing what are analogous to the nodes and loops set up when a sounding tuning fork is held in front of a reflecting wall.

In an electromagnetic wave there are two elements to be considered, the electric currents and the magnetic inductors, and, thinking of it again, according to the mechanical analogy previously discussed, it is evident that the one will be a maximum when the other is a minimum. Just as in an ordinary sound wave the points of rarefaction and condensation are places where the air particles are moving with greatest *velocity*, while midway between these, where the density of the air in the wave is normal, the *displacement* of the air particles from their equilibrium positions is greatest. When a sound wave is reflected from a hard surface, a node or point of rest of the air particles is found at the surface, another such node or point of rest is formed at a distance of one-half a wave length from the reflecting surface by the interference of the advancing with the reflected wave, and between these two nodes there is what is called a loop or a point where the motion of the air particles is a maximum, and so on, we find nodes and loops succeeding each other in regular order, the distance between two successive nodes being half the length of the wave. But while the nodes are places of minimum motion, they are points where the change in density of the air is a maximum. So in the case of electromagnetic waves when reflected from the surface of a conductor; at that surface the changes in magnetic induction will be a maximum, while the changes in the electric displacement will be a minimum; a half wave length from the conducting surface this will be changed; there will be no magnetic induction, while the changes in the electric displacement will be a maximum, and so on alternately, thus constituting electromagnetic nodes and loops. In Fig. 7 the state of things near the reflecting wall in Hertz' experiment is represented, the distances being indicated in metres on the scale at the bottom of the diagram. The vibrator sending out the wave is supposed to be off at the right, with its axis vertical and parallel to the paper, so that in the waves represented electric displacements are up and down in the plane of the paper, while the magnetic lines of induction are perpendicular to the paper.

If at some point on the line from the vibrator perpendicular to the reflecting surface the circle of wire used as a resonator is placed with its plane parallel to the reflecting surface, and with the spark gap neither at the top nor bottom, but at one side, the effect observed will be wholly independent of the magnetic lines of force, since none of them will go through the circle, and since in that position the electric displacements are the same at all points of the circle, the effect will depend only on the intensity of the changes in the displacements; the circle may therefore be used in this way to compare the intensities of the displacement currents at different points. On performing the experiment in this way Hertz found that there was scarcely any sparking when the resonator was near the wall, but that it increased in intensity on carrying it away, reaching a maximum at *B*, then diminished again to a minimum at *C*, and finally increased as the circle was moved toward *D*; the periodicity could not be traced

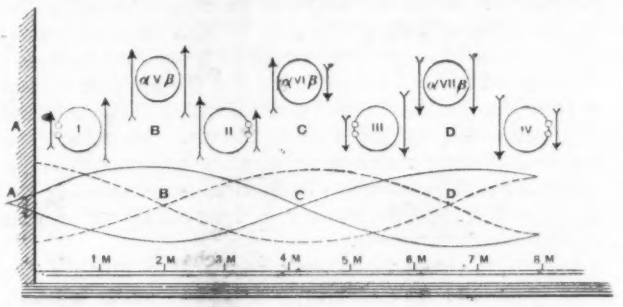


FIG. 7.—DIAGRAM OF ELECTROMAGNETIC WAVES.

farther, owing to the preponderance of the direct waves as the vibrator was approached more nearly. This experiment indicated that the electric displacement was a minimum at the wall, a maximum at the distance *B*, again a minimum at *C*, etc., indicating that the distance from *B* to *C* was one-quarter of a wave length. In this way the length of the wave was found to be 9.3 metres. It will be noticed that in the diagram (Fig. 7) the distance from *B* to the wall is rather less than from *B* to *C*. This is due to the fact that the point at the reflecting surface is not exactly a node, owing to the surface not being a perfect conductor, so that there were slight displacement currents even close to the reflector. That this is the true explanation of the observed phenomena was further shown by determining in a similar way the points where the changes in the magnetic intensity were a maximum. For this purpose the resonator or circle is held with its plane vertical and perpendicular to the reflecting plane, or just as represented in positions I., II., III., IV. in the diagram, except that the spark gap was at the top or bottom instead of at the side, as in the case indicated. In this position of the circle the electric displacements, being up and down, have scarcely any influence in causing sparking to take place at the gap; but the magnetic lines of force, being at right angles to the coil, pass through it, and hence changes in the magnetic induction at the point where the circle is placed give rise to electromotive forces acting around the circle and causing sparks to leap the gap. In this position, therefore, the greatest sparking will be observed where the changes in magnetic induction are greatest. Observation showed marked sparking at the reflecting surface, which fell rapidly to zero as *B* was approached, increased again to a maximum at *C*, then diminished to a second minimum at *D*, and finally increased as the circle was moved beyond *D* nearer to the vibrator, the disturbing influence of the neighborhood of the vibrator being felt as before. These two experiments gave independently the length of the waves sent out by the vibrator, and in accordance with theory showed that the maxima for changes in magnetic induction lay between the points where the electric displacement currents were a maximum. The diagram illustrates this point, vertical distances between the dotted lines representing the intensity of the changes in magnetic induction and the same for the solid lines giving the intensities of the displacement currents.

By these experiments the fact that we are here dealing with a wave motion may be regarded as established and the length of the wave determined. The time of vibration of the electric currents in the vibrator was calculated by Hertz from the form and dimensions of the apparatus as about 2.8 hundred-millionths of a second. If the wave length is divided by the period of vibration the velocity of the wave is obtained. Taking the figures given, we obtain thus 332,000,000 metres per second as the velocity of the wave; but the velocity of light is 300,000,000 metres per second, and the difference between the two may be readily due to an error in the calculated period of vibration of the apparatus, that being a quantity which cannot be accurately computed. It may be concluded, then, that so far as the velocity of the wave is determined by these experiments, they point to the same velocity as that of light.

THE ELECTROMAGNETIC THEORY OF LIGHT.

It is well known that electromagnetic disturbances are communicated from the sun to the earth, as shown in the magnetic disturbances accompanying great sun spot activity. This indicates that some medium fills the region between the earth and sun which is capable of communicating these electromagnetic disturbances, but the medium known as the luminiferous ether, or simply the ether, fills all space as far as light can travel, and it is more rational to suppose this to be the medium also by which electric disturbances are communicated rather than to imagine another medium, at least unless this supposition can be disproved. But the fact that electromagnetic waves are propagated with the same velocity as light waves is almost proof positive of the correctness of the view, since the velocity of a wave depends on the properties of the medium in which it exists, as has been already noted.

Electromagnetic waves are then ether waves; but light waves are also ether waves. What then is the difference between a wave of light and an electromagnetic wave such as is sent out from a Hertz vibrator? The difference is believed to be solely one of wave length, or of the period of the vibration, only those electromagnetic waves affecting the eye as light whose wave length is between one thirty-thousandth of an inch and one seventy-thousandth. It is worth noticing that the period of vibration of electricity on conductors of the dimensions which it is believed the atoms of matter have would be so rapid as to give out waves a hundred times shorter than ordinary light waves; but this is on the assumption that the laws of electric vibration on such minute bodies are the same as for conductors of large size.

There are many striking facts that point to the truth of the electromagnetic theory of light. One has been already adduced, namely, that the velocity in air or in vacuum is the same for light as for electric waves. Again, the velocity of an electromagnetic disturbance depends on the specific inductive capacity of the medium and its magnetic permeability, according to the expression

$$V = \frac{1}{\sqrt{K\mu}}$$

Now the index of refraction of a substance for light is the ratio of the velocity of light in free ether to its velocity in the given substance. If now V', K', μ', apply to some medium such as glass, while V, K, μ, represent the corresponding properties of the ether in vacuum, then the index of refraction of the medium under consideration will be

$$i = \frac{V}{V'} = \sqrt{\frac{K'\mu'}{K\mu}}$$

but if the medium is non-magnetic $\mu = \mu'$, and taking the specific inductive capacity of vacuum as standard = 1, we get

$$i = \sqrt{K'}$$

that is, the index of refraction of a substance for light should be equal to the square root of its specific inductive capacity. Of course, it must be remembered that the alternations or reversals of the electromotive force in case of light are exceedingly rapid compared with the reversals employed in measuring specific inductive capacities, so that the square root of the specific inductive capacity ought to be expected to agree most nearly with the index of refraction of the substance for ultra red rays, or those having the longest wave lengths. The following table exhibits some of the results of experiments testing this point. The index of refraction given is for waves of great length, and is estimated from the way the index changes for wave lengths that can be observed.

Substance.	$\sqrt{K}$	i.
Sulphur	1.96	2.04
Paraffin	1.52	1.54
Turpentine	1.49	1.46
Petroleum	1.43	1.46
Benzine	1.48	1.48

The following values for gases have been found by Boltzmann:

Gas.	$\sqrt{K}$	i.
Air	1.000295	1.000294
Hydrogen	1.000132	1.000138
Carbonic acid	1.000473	1.000449

These are sufficient to show the remarkable agreement observed in many cases. There are, however, substances, such as glass and the fatty oils and electrolytes, which do not show any such close agreement. In the case of glass, for example, $\sqrt{K}$ varies from 2.5 to 3, while the index of refraction is in the neighborhood of 1.5.

It is supposed that this difference is due to the extremely rapid vibrations in the case of light, and that if in deter-

mining K the alternations of electromotive force could be made as rapid that the values of K found would agree with the square of the index of refraction. A partial test of this view has been made by Prof. J. J. Thomson, who has measured K for glass, using the exceedingly rapid alternations of a Hertz vibrator, and it is interesting that the value which he obtains for $\sqrt{K}$ agrees very nearly with the index of refraction, although even the rapid alternations which he employed were a million times slower than those in case of light.

Another test of the electromagnetic theory is afforded by the fact that conductors of electricity should be opaque for electromagnetic waves, and insulators should be transparent. It is obvious that our best conductors are exceedingly opaque bodies, while glass, turpentine, petroleum, shellac, etc., are transparent for light; but there are some difficulties here in the fact that thin gold leaf is more transparent than its conductivity would lead us to expect, while vulcanite, a good insulator, does not seem to be transparent. It is well known, however, that vulcanite is more transparent for long light waves than for shorter ones, and no doubt the explanation of these apparent discrepancies is to be found in the different behavior of the substance to rapid alternations from what is observed in case of slow ones. Perhaps the most signal exception to this rule is found in the case of electrolytes which, though transparent, are good conductors.

The above relations cannot be regarded as mere coincidences. The points of agreement are too many and too significant, and it must be conceded that the difficulties in the way of accepting the theory are in no way so great as are involved in its rejection.

CONCLUSION.

The modern theory of electricity is characterized by its view of the importance of the dielectric medium. In looking at a dynamo supplying energy to a motor the current is no longer regarded as a fluid simply forced around the circuit and having no relation to the surrounding space; but not only is the flow of current always accompanied by magnetic whirls and electric stresses in the medium, but Prof. Paynting has shown that it is through the medium rather than through the wire that the energy is to be regarded as communicated. Thus at the dynamo energy is being given to the medium in setting up lines of magnetic force, and these spreading outwards in every direction gradually grow smaller, forming circles around the wire, and finally collapse into it, their energy being transformed into heat in the wire at the point where they disappear. This spreading out of energetic whirls in the medium and their collapse into the wire where the energy is dissipated as heat continues as long as the current flows. The wire, from this point of view, does not convey the energy, but simply directs the energy which the medium receives at the dynamo, so that it shall be spent at the desired point, being simply a sort of leading string for the energy in providing a place where it may be dissipated in the form of heat, or, as in the motor, in mechanical work. Electrical science may therefore almost be called the science of the ether, for when a magnet attracts a weight it is forced up by the stresses in the ether, and even when a street car moves by a motor it is these same strains and stresses in the ether originating at the dynamo which urge it along.

Electrodynamics of Stationary Bodies.*

BY H. HERTZ.

Steady Flux of Magnetic Force.—If the values of u, v and w are known, we may most readily obtain the components of the magnetic force by making use of an auxiliary quantity called vector potential, whose components U, V, W are given by the equations

$$U = \int \frac{u}{r} dr, \; V = \int \frac{v}{r} dr, \; W = \int \frac{w}{r} dr \qquad (37)$$

These integrals are supposed to be extended throughout all space. From (32) it follows that

$$\frac{d\,U}{d\,x} + \frac{d\,V}{d\,y} + \frac{d\,W}{d\,z} = 0 \qquad (38)$$

and, by making use of this equation, it can be shown that (30) will be satisfied if

$$\left.\begin{aligned} L &= A\left(\frac{d\,V}{d\,z} - \frac{d\,W}{d\,y}\right) \\ M &= A\left(\frac{d\,W}{d\,x} - \frac{d\,U}{d\,z}\right) \\ N &= A\left(\frac{d\,U}{d\,y} - \frac{d\,V}{d\,x}\right) \end{aligned}\right\} \qquad (39)$$

where

$$\frac{d\,L}{d\,x} + \frac{d\,M}{d\,y} + \frac{d\,N}{d\,z} = 0 \qquad (40)$$

As an example, let us consider the force exerted by an element of current at a distant point $x'\ y'\ z'$. If the strength of the current is i, and the element $d\,s$ has components $d\,x$, $d\,y$, $d\,z$, we may in (37) substitute $i\,d\,x = u\,d\,\tau$, $i\,d\,y = v\,d\,\tau$, $i\,d\,z = w\,d\,\tau$; and, if we regard the magnetic force exerted by the current as the sum of the forces exerted by each element separately, we obtain for the element in question, when the point $x'\ y'\ z'$ lies in the plane $x'\ y'$

$$L = 0 \qquad M = 0$$

$$N = A\,i\,d\,x\,\frac{d\,\frac{1}{r}}{d\,y'} = -\frac{A\,i\,d\,x}{r^2}\,\frac{y'}{r}$$

Continued from The Electrical World, Nov. 8, 1890.

which expresses Ampère's rule and the law of Biot and Savart.

Reference to equations (30) will show that whenever u, v, and w vanish, as they do outside a conductor, the values of L, M, N can be obtained by differentiating a potential function, ψ, with regard to x, y, z respectively, and afterwards changing the sign. If the forces are the result of a single closed current, i, the potential ψ takes the form

$$\psi = -A\,i\int d\,\frac{1}{\frac{r}{d\,n}}\,d\,w + \text{a constant} \qquad (41)$$

where $d\,w$ is an element of a surface bounded by the current contour; n is a length drawn in the direction of the normal; and the integration is extended all over the surface so bounded. That side of the surface is to be considered positive from which the current appears to circulate in a clockwise direction. The derivatives of ψ are finite and continuous everywhere outside the currents; and if at the surface, w, the value of ψ becomes discontinuous, we may regard the constant as not absolutely fixed, and by increasing its value by $4\,\pi\,A\,i$ each time the path of integration crosses the surface, the function ψ becomes quite continuous from point to point, although it is many-valued.

The integral expression for ψ is susceptible of several interpretations. In the first place, we may consider it as the potential due to a double magnetic layer, and this view leads naturally to Ampère's theory of magnetism.

On the other hand, we may consider, with Gauss, that the value of ψ represents the spherical angle subtended, at the point in question, by the current contour. This method of regarding the matter enables us to see the exactitude of the statement that the value of the integral at any point is equal to the number of the lines of force which start from a unit pole placed at the point, and are inclosed by the current contour.

It is, moreover, always true that the difference in the value of ψ at two points is equal to the product of $A\,i$, and the number of lines of force which cut the electric circuit when a unit magnetic pole is moved in any way whatever from the first point to the second.

It is this last interpretation which it is most useful for us to consider. It follows that the mechanical work necessary to bring up a magnetic pole or other invariable magnetic system to a circuit traversed by a constant current i is measured by the product of $A\,i$ and the number of lines of force due to the magnetic system, which are cut, during the movement, by the electric circuit. Similarly, the mechanical work required to displace a circuit through which a constant current i is flowing is measured by the product of $A\,i$ and the number of lines cut by the current during the displacement.

Finally, the mechanical work required to displace two electric circuits traversed by constant currents is equal, either to the product of the constant A, the strength of the first current, and the number of lines due to the second current and cut by the first during the displacement, or to the product of the constant A, the strength of the second current, and the number of lines due to the first current and cut by the second as the result of the movement. The two expressions lead to the same result; for, if we distinguish by dashes quantities referring to the second current, we have for the first expression:

$$A\,i\int [L'\cos(n,x) + M'\cos(n,y) + N'\cos(n,z)]\,d\,w,$$

and this, by suitable transformations, can be shown to be equivalent to

$$-A^2\,i\,i'\int\int \frac{\cos\varepsilon}{r}\,d\,s\,d\,s',$$

where $d\,s$, $d\,s'$ are elements of the two electric circuits, at a distance r from each other, and inclined at an angle ε. Since this expression is symmetrical for the two circuits, the foregoing statement is verified. The product of $A^2\,i\,i'$ and the variation of Neumann's potential represents the work needed to produce any displacement, and its rate of variation thus determines the mechanical force exerted between the two circuits when at rest. The expression for the force thus obtained contains all that we know with certainty regarding the mechanical forces exerted by currents.

DYNAMICAL PHENOMENA.

Up to the present, among the great variety of possible forms of the variable state, only a very small group of phenomena has been observed.

Induction in Closed Circuits.—The electric forces arising in a variable magnetic field are in general very feeble, because they contain a very small factor, the constant A [see (10) and (11)]; and the perception of these forces is only possible when they produce currents in closed circuits, or when their actions accumulate in linear circuits which are well nigh closed.

The actions which can be measured in researches are always the result of the integral action of the electric force taken around a closed circuit, and represented by the expression

$$\int (X\,d\,x + Y\,d\,y + Z\,d\,z).$$

By transforming this line integral into a surface integral, and by making use of (10), it is possible to show that this expression is equivalent to

$$A\,\frac{d}{dt}\int [L\cos(n,x) + M\cos(n,y) + N\cos(n,z)]\,d\,w,$$

or to the product of A, and the rate at which lines of force cut the circuit.

In particular, if the induction is produced by a variable closed current, and if there are no magnetizable bodies in the neighborhood, the induced electromotive force is equal to the product of A^2, the time rate of change of the inducing current, and the potential of Neumann with reference to the two circuits.

These two principles, of which the former is the more general, embrace all induction phenomena which have been observed in stationary conductors.

The induction which takes place in moving conductors is, strictly speaking, not included in the field covered by the present paper. We may, however, for linear conductors, connect this case with those already studied, by making use of the following principle. The electromotive force induced in a circuit will have the same value, whether the variation of the surrounding magnetic field is produced by the movement of ponderable bodies, or by purely electromagnetic phenomena, provided only that the variation is the same in the two cases.

It follows that the electromotive force generated in a moving circuit is equal to the product of A and the rate at which lines of force are cut by the circuit. The product of this electromotive force and the strength of the current in the moving conductor represents the rate at which chemical or thermal energy is generated by the induction.

This energy can also be shown to be equal to the mechanical work done by the exterior moving forces during the motion. Thus if a circuit conveying a constant current is moved in the neighborhood of a fixed magnet, the work required to produce the movement is the exact equivalent of the thermal or chemical energy generated in the circuit, provided the magnetic energy of the system does not change. If, on the other hand, two circuits conveying constant currents are moved with reference to each other, the thermal or chemical energy appearing in one of the circuits compensates the mechanical energy absorbed by the motion, while the energy appearing in the other circuit compensates exactly the loss of the electromagnetic energy of the system. In other words, the total energy produced is the exact equivalent of the energy destroyed.

Unclosed Circuits.—The extent of this subject is apparently the largest of all, as it embraces all those problems which cannot be considered as particular cases of the other subjects. However, having regard to the experiments actually possible, this subject is the poorest of all.

The oscillations which are produced in unclosed induction coils, or by the discharge of Leyden jars, can be studied with sufficient approximation by means of the principles established in the preceding sections. Properly speaking, electrical waves and the oscillations occurring with short waves belong to this chapter. It must be observed that a division of the electric force into an electrostatic force and an electrodynamic one in these general problems has no clear or precise physical significance, nor does it yield any valuable mathematical advantage. This method of study we therefore abandon in favor of others which are more convenient and fruitful.

Movement of Light in Isotropic Bodies.—We consider the domain of optics to embrace all electrodynamic movements which are periodic with regard to time, and which are so rapid that at least a thousand million periods occur in a single second.

Let us restrict ourselves to bad conductors, which are homogeneous and isotropic. We then obtain from equations (1) and (2) by elimination

$$A^2\,\varepsilon\,\mu\,\frac{d^2\,\theta}{d\,t^2} = \triangle\,\theta \qquad (42)$$

where $\triangle$ stands for the operator $\frac{d^2}{d\,x^2} + \frac{d^2}{d\,y^2} + \frac{d^2}{d\,z^2}$ and where we may substitute for θ either L, M, N, X, Y, or Z.

We also have from (3)

$$\frac{d\,L}{d\,x} + \frac{d\,M}{d\,y} + \frac{d\,N}{d\,z} = 0 \qquad (43)$$

$$\frac{d\,X}{d\,x} + \frac{d\,M}{d\,y} + \frac{d\,N}{d\,z} = 0 \qquad (44)$$

The solution for θ in (42) is a periodic function, representing a wave whose vibrations are transverse to the direction of propagation. The velocity of propagation is for all possible waves equal to the reciprocal of $A\sqrt{\varepsilon\,\mu}$, and the phenomena of rectilinear propagation, reflection, interference of natural and polarized light, and various types of polarization can all be explained as a consequence of such wave propagation. On further reference to equations (1) and (2) we see that at each point on a plane wave the directions of the simultaneous electric and magnetic forces are perpendicular to each other.

Suppose that the surface separating the two non-conductors is the plane of $x\,y$. We have in this case, since we are only considering periodic movements—

$$L_1 = L_2 \qquad X_1 = X_2$$
$$M_1 = M_2 \qquad Y_1 = Y_2$$
$$\mu_1\,N_1 = \mu_2\,N_2 \qquad \varepsilon_1\,Z_1 = \varepsilon_2\,Z_2$$

Each of these systems of equations which hold at the surface in conjunction with those which are true within the media yield the laws of reflection, refraction, and of total reflection; that is to say, the fundamental laws of geometrical optics. Each of these systems shows also that the intensities of reflected and refracted waves depend on the plane of polarization. They yield the same formulæ as Fresnel gave for these relations, and also for the retardation of phase occurring in total reflection.

If to obtain these formulæ we make use of the electric forces (equations (42) and (43), substituting L, M or N for ϕ) we pursue a method analogous to that of Fresnel. If, on the contrary, we make use of the magnetic equations [see (42) and (44), substituting X, Y or Z for ϕ] we follow a course pursued by Neumann in obtaining Fresnel's formulæ. From our point of view not only must the two methods yield the same result, but they can be described as being equally correct. It is, however, the electrical properties of bodies which mostly determine their optical behavior. In the phenomena of reflection actually observed the electrical and magnetic forces have not exactly the same effect since the magnetic constant of nearly all bodies is close to unity,

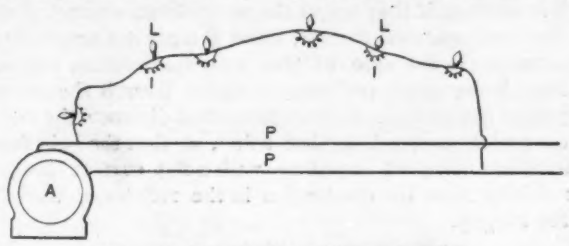


FIG. 48.—DIAGRAM OF DISTRIBUTION.

while the electric constant varies enormously for different media.

If the plane of $x\ y$ separates a bad conductor from a perfect conductor, we have

$$W = 0 \qquad X = 0 \qquad Y = 0.$$

These equations, in conjunction with those holding good for the interior of bad conductors, show that reflection is total at the separating surface, whatever the angle of incidence and the azimuth of the plane of polarization.

It is known that real conductors occupy an intermediate position between bad conductors and perfect ones, and this is why reflection at their surface is a mixture of total reflection, and reflection such as occurs ordinarily at the surface of transparent bodies. As metallic reflection behaves in the same way, we can conclude that it is represented by our equations.

Optics of Crystals.—In the interior of homogeneous, perfectly transparent crystals, we shall make the supposition that the axes of symmetry of the electric energy coincide with the axes of symmetry of the magnetic energy. We shall take these axes as our axes of x, y, z; and, since for crystals the value of ε and μ vary with direction, we shall have to substitute μ_1, μ_2, μ_3 for μ in the three equations (1), and ε_1, ε_2, ε_3 for ε in equations (2). Solving these new equations, and obtaining the wave surface for periodic disturbances, we obtain a surface represented by an equation of the sixth degree. This, however, reduces to the well-known surface of Fresnel, if we put $\mu_1 = \mu_2 = \mu_3$, which is very approximately true. Thus all the phenomena of double refraction, and of reflection and interference occurring with crystals, can be explained on ordinary optical methods. With reference to the wave surface, we can establish the following statements: The magnetic force is perpendicular to the electric polarization, and the electric force to the magnetic polarization. The direction of the two forces is, in general, outside the surface of the wave; but each direction of polarization is tangential. The direction perpendicular to the two polarizations is consequently normal to the wave; while the direction perpendicular to the two forces is that in which energy is being propagated, and, in optics, this latter direction is called the direction of the luminous ray.

Electrical Distribution by Transformers from Central and Eccentric Stations.*

BY DR. J. A. FLEMING, M. A.

§ 15. *Typical Westinghouse Transformer Stations.*—One of the largest stations for the supply of electric current by the Westinghouse transformer system is at Pittsburgh, Pa., in the United States. The boilers at this station are of the water-tube type, heated by natural gas. The engines are the well-known standard Westinghouse engines, and stand on square blocks of concrete or masonry, the blocks for the size used, 250 h. p., being about 7 feet by 5 feet. Five of these engines drive five alternating current dynamos, each having a capacity for 2,500 16 c. p. incandescent lamps. Besides this there is a Corliss engine, driving another dynamo. The exciters are driven from separate smaller engines. The engines driving the alternating dynamos make 250 revolutions per minute, and the dynamos 1,050. The power of the engines is conveyed to the dynamos, which are placed on a floor above, by belts. Each dynamo is fixed on a sliding bed, so that the belt can be tightened. The general construction of these alternators has been described in a previous section. From the dynamos the mains are run to the switch board in troughs cut in the joists supporting the floor. The switch board at Pittsburgh is about 9 feet high and 14 feet long, and stands away from the wall of the dynamo room about 3 feet to enable access to be had behind it for making all connections.

One single exciter dynamo is used, another being in reserve to provide exciting current for several machines, and convenient switches are placed on the board to enable the excitation to be effected by either of the exciters. The general details of the board, as well as the arrangements for measuring and regulating the pressure at the far end of each feeder, have been already described. This station furnishes current for about 13,000 incandescent lamps (1890).

A very typical Westinghouse station, operating overhead primary conductors, is that at East Liberty, Pa., U. S. A. The service from this station covers a very extended area, comprising the business portion of the city, which lies at an average distance of a half a mile from the station, ramifying through an extended series of residence streets and carrying a special line to a distant suburb in which the last lamp is 4½ miles from the dynamo. The arrangement of the building is shown in Fig. 47. A one-storied brick building contains offices, stores, dynamos and boiler room. The plant has an aggregate capacity of about 8,000 lights. Dynamos and engines are on the same floor, every part of which is under the eye of a single attendant. The engines and dynamos stand on brick foundations. Each engine is belted to its own dynamo. The steam pipe is brought along overhead, and the engines exhaust into a main laid in a covered trench underneath the floor. Two exciters are provided as shown on the left of the dynamo room, each adequate to supply current to the entire station, and each driven independently by its own engine. Only one exciter and engine is operated at once. The position of the exciters and engines is such that by changing a belt either engine can drive either exciter. Two overhead cranes traverse the whole length of the buildings over the engines and dynamos. Using natural gas to fire the boilers, attendance is reduced to a minimum, and one attendant in the dynamo room can give all necessary attention to the engines, dynamos, exciters, and switchboard. The reduction of labor to a minimum is especially made an object in the design of these American stations.

In connection with these transformer stations, a system of street incandescent lighting has been worked out, which is very efficient, and enables a large amount of street lighting over scattered areas to be taken up, but which would not be remunerative if primary mains and transformers had to be placed along the whole route. Starting anywhere from one primary main or feeder, P

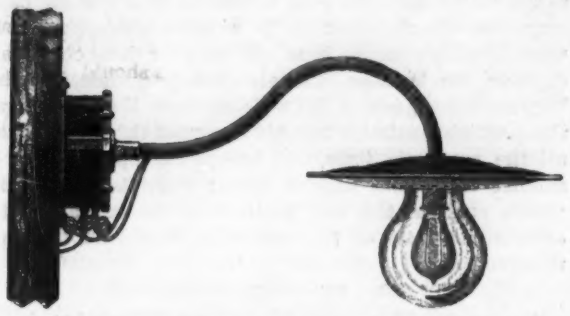


FIG. 50.—SERIES STREET LAMP AND IMPEDANCE COIL.

(see Fig. 48), a single line is run following the route of the proposed street lighting; and at every place where a street light, L, is required, an impedance or choking coil, I, is placed having a low resistance series incandescent lamp across its terminals. This line is then so run that it terminates at some distant spot on the other member of that same primary line or feeder. Suppose that the primary pressure is 1,000 volts, and that 10-volt low resistance lamps are used, there can be 100 such coils and lamps on that series line. The impedance coil is contained in a box on the bracket that carries the lamp (see Figs. 49, 50). If any lamp breaks, the impedance coil is thereby thrown into the circuit, and lowers the current just by that amount which keeps the rest of the lamps on that circuit from being over burnt. Hence the breakage of any of the lamps does not affect the light of the rest, nor does the removal of one lamp in any way affect the operation of the others, although the lamps are all in series.

(*To be continued.*)

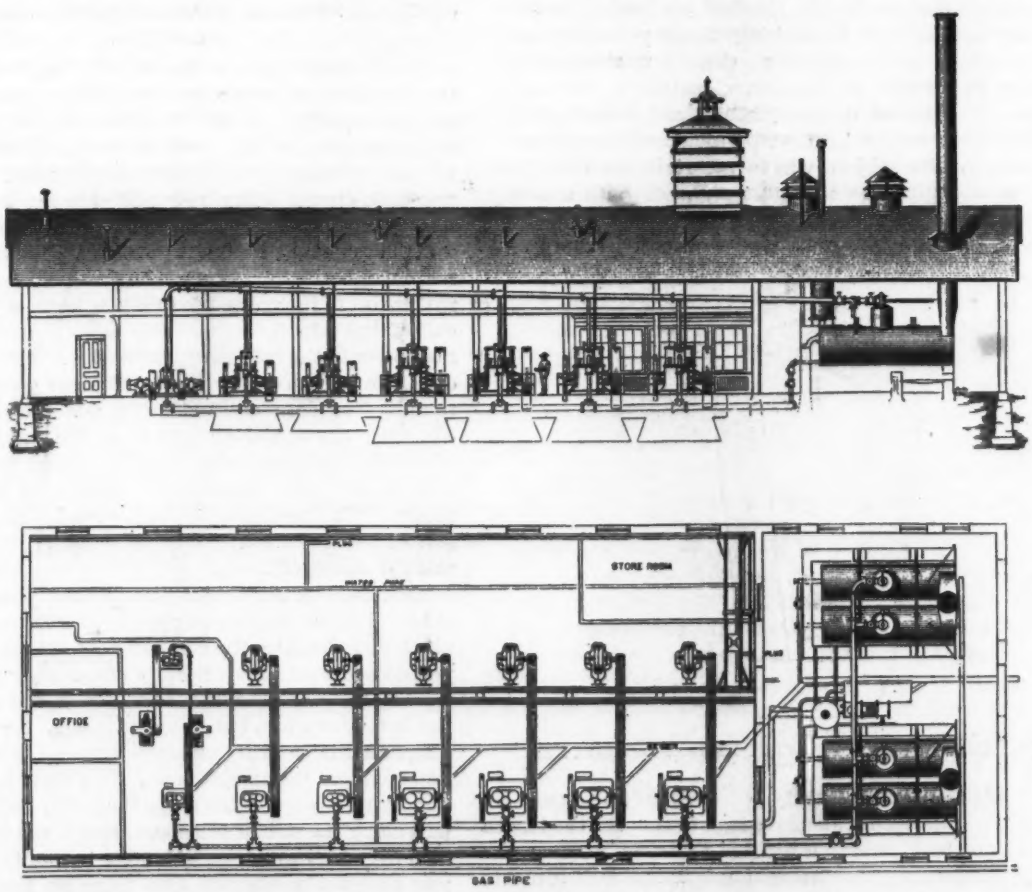


FIG. 47.—ELEVATION AND PLAN OF WESTINGHOUSE CENTRAL STATION AT EAST LIBERTY, PA.

*Continued from the ELECTRICAL WORLD, Nov. 8, 1890.

Shocked by a Moving Footplate.

There was a curious scene in Paris the other day (writes a correspondent of the London *Daily News*) just outside the Opera House. Traffic was in full swing, when a lady who was crossing the street and had got on to one of the refuges sunk to the ground with a scream. She had put her foot on a large metal plaque, and immediately felt an electric shock. The usual crowd collected, and the usual police arrived. But the cause was clear to all. Quite close to the scene of the accident was a standard of clustered electric lights, and the wire which supplied the current passed close to the metal plate. With great presence of mind the police sent for several electricians, keeping a cordon in the meantime round the plaque. The experts went to work quickly and cautiously. The metal plate itself was raised. It communicated with one of the subterranean passages that lead to the drainage system of the city. Then at last the cause of the accident was discovered. A workman employed in the drains wanted to emerge, and happened to push up the plate at the moment the lady's foot was on it. Hence the earthquake and the shock. Thereupon the crowd dispersed, the electricians went home, the police preserved impenetrable silence, and the lady, who really showed considerable imagination, decided to say as little as possible about the accident.

FIG. 49.—WESTINGHOUSE IMPEDANCE COIL FOR SERIES LIGHTING.

The Electromagnet.*

BY PROF. SILVANUS P. THOMPSON, D. SC., B. A., M. I. E. E.

EFFECT OF SIZE OF COILS.

Seeing that the magnetizing power which a coil exerts on the magnetic circuit which it surrounds is simply proportional to the ampère-turns, it follows that those turns which lie on the outside layers of the coil, though they are further away from the iron core, possess precisely equal magnetizing power. This is strictly true for all closed magnetic circuits; but in those open magnetic circuits where leakage occurs it is only true for those coils which encircle the leakage lines also. For example, in a short bar electromagnet, of the wide turns on the outer layer, those which encircle the middle part of the bar do inclose all the magnetic lines, and are just as operative as the smaller turns that underlie them; while those wide turns which encircle the end portions of the bar are not so efficient, as some of the magnetic lines leak back past these coils.

EFFECT OF POSITIONS OF COILS.

Among the other researches which Du Moncel made with respect to electromagnets was one on the best position for placing the coil upon the iron core. This is a matter that other experimenters have examined. In Dub's book, "Electromagnetismus," to which I have several times referred, you will also find many experiments on the first position of a coil; but it is perhaps sufficient to narrate a single example. Du Moncel had four pairs of bobbins made of exactly the same length, and with 50 metres of wire on each; one pair was 16 centimetres long, another pair 8 centimetres, or half the length, with not quite so many turns —because of course the diameter of the outer turn was larger —one 4 centimetres in length and another 2 centimetres. These were tried both with bar magnets and horseshoes. It will suffice, perhaps, to give the result of the horseshoe. The horseshoe was made long enough—16 centimetres only, a little over 6 inches long —to carry the longest coil. Now when the compact coils 2 centimetres long were used, the pull on the armature at a distance away of 2 millimetres (it was always the same, of course, in the experiments) was 40 grammes. Using the same weight of wire, but distributed on the coils twice as long, the pull was 55 grammes. Using the coils 8 centimetres long, it was 75 grammes, and using the coils 16 centimetres long, covering the length of each limb, the pull was 85, clearly showing that, where you have a given length of iron, the best way of winding a magnet to make it pull with its greatest pull is not to heap the coil up against the poles, but to wind it uniformly; for this mode of winding will give you more turns, therefore more ampère-turns, therefore more magnetization. An exception might, however, occur in some case where there is a large percentage of leakage. With club-footed magnets results of the same kind are obtained. It was found in every case that it was well to distribute the coil as much as possible along the length of the limb. All these experiments were made with a steady current. It does not follow, however, because winding the wire over the whole length of core is best for steady currents that it is the best winding in the case of a rapidly varying current; indeed, we shall see that it is not.

EFFECT OF SHAPE OF SECTION.

So far as the carrying capacity for magnetic lines is concerned, one shape of section of cores is as good as another; square or rectangular is as good as round if containing equal sectional area. But there are two other reasons, both of which tell in favor of round cores. First, the leakage of magnetic lines from core to core is, for equal mean distances apart, proportional to the surface of the core; and the round core has less surface than square or rectangular of equal section. All edges and corners, moreover, promote leakage. Secondly, the quantity of copper wire that is required for each turn will be less for round cores than for cores any other shape, for of all geometrical figures of equal area the circle is the one of the least periphery.

EFFECT OF DISTANCE BETWEEN POLES.

Another matter that Du Moncel experimented upon, and Dub and Nicklès likewise, was the distance between the poles. Dub considered that it made no difference how far the poles were apart. Nicklès had a special arrangement made which permitted him to move the two upright cores or limbs, nine centimetres high, to and fro on a solid bench or yoke of iron. His armature was 30 centimetres long. Using very weak currents, he found the effect best when the shortest distance between the poles was three centimetres; with a stronger current, 12 centimetres; and with his strongest current, nearly 30 centimetres. I think leakage must have a deal to do with these results. Du Moncel tried various experiments to elucidate this matter, and so did Professor Hughes in an important but too little known research, which came out in the *Annales Télégraphiques* in the year 1862.

RESEARCHES OF PROFESSOR HUGHES.

His object was to find out the best form of electromagnet, the best distance between the poles, and the best form of armature for the rapid work required in Hughes' printing telegraphs. One word about Hughes' magnets. This diagram (Fig. 51) shows the form of the well known Hughes electromagnet. I feel almost ashamed to say those words "well known," because although on the Continent everybody knows what you mean by a Hughes magnet, in England next to no one knows what you mean; in fact, they do not know what Hughes' magnet is. They do not even know that Professor Hughes ever invented a special form of electromagnet. Hughes' special form is this: A permanent steel magnet, generally a compound one, having soft iron pole-pieces, and a couple of coils on the pole-pieces only. As I have to speak of Hughes' special contrivance amongst the mechanisms that will occupy our attention next week, I only now refer to this magnet in one particular. If you wish a magnet to work rapidly, you will secure the most rapid action, not when the coils are distributed all along, but when they are heaped up near, not necessarily entirely on, the poles.

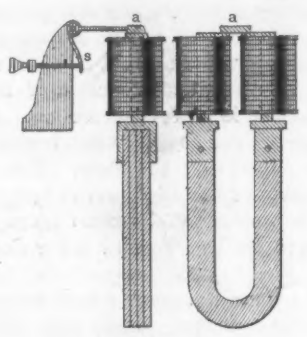


Fig. 51.—Hughes' Electromagnet.

Hughes made a number of researches to find out what the right length and thickness of these pole-pieces should be. It was found an advantage not to use too thin pole-pieces, otherwise the magnetism from the permanent magnet did not pass through the iron without considerable resistance, being choked by insufficiency of section; also not to use too thick pieces, otherwise they presented too much surface for leakage across from one to the other. Eventually a particular length was settled upon, in proportion about six times the diameter, or rather longer. In the further researches that Hughes made he used a magnet of shorter form, not shown here, more like those employed in relays, and with an armature from 2 to 3 millimetres thick, 1 centimetre wide, and 5 centimetres long. The poles were turned over at the top toward one another. Hughes tried whether there was any advantage in making those poles approach one another, and whether there was any advantage in having as long an armature as five centimetres. He tried all different kinds, and plotted out the results of observations in curves, which could be compared and studied. His object was to ascertain the conditions which would give the strongest pull, not with a steady current, but with such currents as were required for operating his printing telegraph instruments; currents which

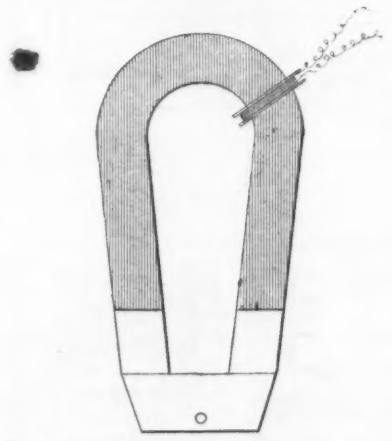


Fig. 52.—Experiment with Permanent Magnet.

lasted only from one to twenty hundredths of a second. He found it was decidedly an advantage to shorten the length of the armature, so that it did not protrude far over the poles. In fact, he got a sufficient magnetic circuit to secure all the attractive power that he needed, without allowing as much chance of leakage as there would have been had the armature extended a longer distance over the poles. He also tried various forms of armature having very various cross-sections.

POSITION AND FORM OF ARMATURE.

In one of Du Moncel's papers on electro magnets* you will also find a discussion on armatures, and the best forms for working in different positions. Amongst other things in Du Moncel you will find this paradox; that whereas, using a horseshoe magnet with flat poles, and a flat piece of soft iron for armature, it sticks on far tighter when put on edgeways, on the other hand, if you are going to work at a distance, across air, the attraction would be far greater if you set it flatways. I explained the advantage of narrowing the surfaces of contact by the law of traction, B^2 coming in. Why should we have for an action at a distance the greater advantage from placing the armature flatway to the poles. It is simply that you thereby reduce the reluctance offered by the air gap to the flow of the magnetic lines. Du Moncel also tried the difference between round armatures and flat ones, and found that a cylindrical armature was only attracted about half as strongly as a prismatic armature having the same surface when at the same distance. Let us examine this fact in the light of the magnetic circuit. The poles are flat. You have at a certain distance away a round armature; there is a certain distance between its nearest side and the polar surfaces. If you have at the same distance away a flat armature having the same surface, and, therefore, about the same tendency to leak, why do you get a greater pull in this case than in that? I think it is obvious, if they are at the same distance away, giving the same range of motion, there is a greater magnetic reluctance in the case of the round armature, although there is the same periphery, because though the greatest part of the surface is at the prescribed distance, the rest of the under surface is farther away, so that the gain found in substituting an armature with a flat surface is a gain resulting from the diminution in the resistance offered by the air gap.

POLE-PIECES ON HORSESHOE MAGNETS.

Another of Du Moncel's researches* relates to the effect of polar projections or shoes—movable pole-pieces, if you like—upon a horseshoe electromagnet. The core of this magnet was of round iron 4 centimetres in diameter, and the parallel limbs were 10 centimetres long and 6 centimetres apart. The shoes consisted of two flat pieces of iron slotted out at one end, so that they could be slid along over the poles and brought nearer together. The attraction exerted on a flat armature across air gaps 2 millimetres thick was measured by counterpoising. Exciting this electromagnet with a certain battery, it was found that the attraction was greatest when the shoes were pushed to about 15 millimetres, or about one-quarter of the inter-polar distance, apart. The numbers were as follows:

Distance between shoes. Millimetres.	Attraction in grammes.
2	900
10	1,012
15	1,025
25	965
40	890
60	550

With a stronger battery the magnet without shoes had an attraction of 885 grammes, but with the shoes 15 millimetres apart, 1,195 grammes. When one pole only was employed, the attraction, which was 88 grammes without a shoe, was *diminished* by adding a shoe to 39 grammes!

CONTRAST BETWEEN ELECTROMAGNETS AND PERMANENT MAGNETS.

Now, I want particularly to ask you to guard against the idea that all these results obtained from electromagnets are equally applicable to permanent magnets of steel; they are not for this simple reason. With an electromagnet, when you put the armature near, and make the magnetic circuit better, you not only get more magnetic lines going through that armature, but you get more magnetic lines going through the whole of the iron. You get more magnetic lines round the bend when you put an armature on to the poles, because you have a magnetic circuit of less reluctance, with the same external magnetizing power in the coils acting around it. Therefore, in that case, you will have more magnetic lines going all the way round. The data obtained with the electromagnet (Fig. 43), with the exploring coil *C* on the bend of the core, when the armature was in contact and when it was removed, are most significant. When the armature was present it multiplied the total magnetic flow tenfold for weak currents and nearly threefold for strong currents. But with a steel horseshoe, magnetized once for all, the magnetic lines that flow around the bend of the steel are a fixed quantity, and, however much you diminish the reluctance of the magnetic circuit, you do not create or evoke any more. When the armature is away the magnetic lines arch across, not at the ends of the horseshoe only, but from its flanks, the whole of the magnetic lines leaking somehow across the space. When you have put the armature on, these lines, instead of arching out into space as freely as they did, pass for the most part along the steel limbs and through the iron armature. You may still have a considerable amount of leakage, but you have not made one line more go through the bent part. You have absolutely the same number going through the bend with the armature off as with the armature on. You do not add to the total number by reducing the magnetic reluctance, because you are not working under the influence of a constantly impressed magnetizing force. By putting the armature on to a steel horseshoe magnet you only *collect* the magnetic lines, you do not *multiply* them. This is not a matter of conjecture. A group of my students have been making experiments in the following way: They took this large steel horseshoe magnet (Fig. 52), the length of which from end to end through the steel is 42¼ inches. A light narrow frame was constructed, so that it could be slipped on over the magnet, and on it were wound 30 turns of fine wire, to serve as an exploring coil. The ends of this coil were carried to a distant part of the laboratory, and connected to a sensitive ballistic galvanometer. The mode of experimenting is as follows: The coil is slipped on over the magnet (or over its armature) to any desired position. The armature of the

*Cantor Lectures, No. 3, continued from The Electrical World, Nov. 8, 1890.

* "La Lumière Electrique," Vol. II.

* "La Lumière Electrique," Vol. IV., p. 129.

magnet is placed gently upon the poles, and time enough is allowed to elapse for the galvanometer needle to settle to zero. The armature is then suddenly detached. The first swing measures the change, due to removing the armature, in the number of magnetic lines that pass through the coil in the particular position.

I will roughly repeat the experiment before you; the spot of light on the screen is reflected from my galvanometer at the far end of the table. I place the exploring coil just over the pole, and slide on the armature; then close the galvanometer circuit. Now I detach the armature, and you observe the large swing. I shift the exploring coil, right up to the bend; replace the armature; wait until the spot of light is brought to rest at the zero of the scale. Now, on detaching the armature, the movement of the spot of light is quite imperceptible. In our careful laboratory experiments the effect was noticed inch by inch all along the magnet. The effect when the exploring coil was over the bend was not as great as 1-3,000th part of the effect when the coil was hard up to the pole. We are therefore justified in saying that the number of magnetic lines in a permanently magnetized steel horseshoe magnet is not altered by the presence or absence of the armature.

You will have noticed that I always put on the armature gently. It does not do to slam on the armature; every time you do so you knock some of the so-called permanent magnetism out of it. But you may pull off the armature as suddenly as you like. It does the magnet good rather than harm. There is a popular superstition that you ought never to pull off the keeper of a magnet suddenly. On investigation, it is found that the facts are just the other way. You may pull off the keeper as suddenly as you like; but you should never slam it on.

From these experimental results I pass to the special design of electromagnets for special purposes.

ELECTROMAGNETS FOR MAXIMUM TRACTION.

These have already been dealt with in the preceding lecture; the characteristic feature of all the forms suitable for traction being the compact magnetic circuit.

Several times it has been proposed to increase the power of electromagnets by constructing them with intermediate masses of iron between the central core and the outside, between the layers of windings. All these constructions are founded on fallacies. Such iron is far better placed either right inside the coils or right outside them, so that it may properly constitute a part of the magnetic circuit. The constructions known as Camacho's and Cance's, and one patented by Mr. S. A. Varley in 1877, belonging to this delusive order of ideas, are now entirely obsolete.

Another construction which is periodically brought forward as a novelty is the use of iron windings of wire or strip in place of copper winding. The lower electric conductivity of iron, as compared with copper, makes such a construction wasteful of exciting power. To apply equal magnetizing power by means of an iron coil implies the expenditure of about six times as many watts as need be expended if the coil is of copper.

ELECTROMAGNETS FOR MAXIMUM RANGE OF ATTRACTION.

We have already laid down the principle which will enable us to design electromagnets to act at a distance. We want our magnet to project, as it were, its force across the greatest length of air gap. Clearly, then, such a magnet must have a very large magnetizing power, with many ampère-turns upon it, to be able to make the required number of magnetic lines pass across the air resistance. Also it is clear that the poles must not be too close together for its work, otherwise the magnetic lines at one pole will be likely to coil round and take short cuts to the other pole. There must be a wider width between the poles than is desirable in electromagnets for traction.

ELECTROMAGNETS OF MINIMUM WEIGHT.

In designing an apparatus to put on board a boat or a balloon, where weight is a consideration of primary importance, there is again a difference. There are three things that come into play—iron, copper, and electric current. The current weighs nothing; therefore if you are going to sacrifice everything else to weight, you may have comparatively little iron; but you must have enough copper to be able to carry the electric current; and under such circumstances you must not mind heating your wires nearly red hot to pass the biggest possible current. Provide as little copper as you conveniently can, sacrificing economy in that case to the attainment of your object; but, of course, you must use fire-proof material, such as asbestos, for insulating, instead of cotton or silk.

A USEFUL GUIDING PRINCIPLE.

In all cases of design there is one leading principle which will be found of great assistance; namely, that a magnet always tends so to act as though it tried to diminish the length of its magnetic circuit. It tries to grow more compact. This is the reverse of that which holds good with an electric current. The electric circuit always tries to enlarge itself, so as to inclose as much space as possible, but the magnetic circuit always tries to make itself as compact as possible. Armatures are drawn in as near as can be, to close up the magnetic circuit. Many two-pole electromagnets show a tendency to bend together when the current is turned on. One form in particular, which was devised by Ruhmkorff for the purpose of repeating Faraday's celebrated experiment on the magnetic rotation of polarized light, is liable to this defect. Indeed, this form of electromagnet is often designed very badly, the yoke being too thin, both mechanically and magnetically, for the purpose which it has to fulfill.

Here is a small electric bell, constructed by Wagener, of Wiesbaden, the construction of which illustrates this principle. The electromagnet, a norseshoe, lies horizontally; its poles are provided with protruding, curved pins of brass. Through the armature are drilled two holes, so that it can be hung upon the two brass pins, and when so hung up it touches the ends of the iron cores just at one edge, being held from more perfect contact by a spring. There is no complete gap, therefore, in the magnetic circuit. When the current comes and applies a magnetizing power, it finds the magnetic circuit already complete in the sense that there are no absolute gaps. But the circuit can be bettered by tilting the armature to bring it flat against the polar ends, that being

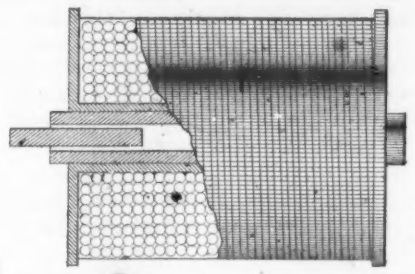


FIG. 53.—ELECTROMAGNETIC POP-GUN.

indeed the mode of motion. This is a most reliable and sensitive pattern of bell.

Electromagnetic Pop-gun.—Here is another curious illustration of the tendency to complete the magnetic circuit. Here is a tubular electromagnet (Fig. 53), consisting of a small bobbin, the core of which is an iron tube about two inches long. There is nothing very unusual about it; it will stick on, as you see, to pieces of iron when the current is turned on. It clearly is an ordinary electromagnet in that respect. Now, suppose I take a little round rod of iron, about an inch long, and put it into the end of the tube, what will happen when I turn on my current? In this apparatus as it stands the magnetic circuit consists of a short length of iron, and then all the rest is air. The magnetic circuit will try to complete itself, not by shortening the iron, but by *lengthening* it; by pushing the piece of iron out so as to afford more surface for leakage. That is exactly what happens; for, as you see, when I turn on the current the little piece of iron shoots out and drops down. You see that little piece of iron shoot out with considerable force. It becomes a sort of magnetic pop-gun. This is an experiment which has been twice discovered. I found it first described by Count Du Moncel, in the pages of "La Lumière Electrique," under the name of the "pistolet électromagnétique;" and Mr. Shelford Bidwell invented it independently. I am indebted to him for the use of this apparatus. He gave an account of it to the Physical Society in 1885, but the reporter missed it, I suppose, as there is no record in the Society's proceedings.

ELECTROMAGNETS FOR USE WITH ALTERNATING CURRENTS.

When you are designing electromagnets for use with alternating currents, it is necessary to make a change in one respect, namely, you must so laminate the iron that internal eddy-currents shall not occur; indeed, for all rapid acting electromagnetic apparatus it is a good rule that the iron must not be solid. It is not usual with telegraphic instruments to laminate them by making up the core of

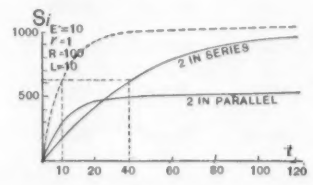


FIG. 54.—CURVES OF RISE OF CURRENTS.

bundles of iron plates or wires, but they are often made with tubular cores; that is to say, the cylindrical iron core is drilled with a hole down the middle, and the tube so formed is slit with a saw-cut to prevent the circulation of currents in the tube. Now, when electromagnets are to be employed with rapidly alternating currents, such as are used for electric lighting, the frequency of the alternations being usually about 100 periods per second, slitting the cores is insufficient to guard against eddy-currents; nothing short of completely laminating the cores is a satisfactory remedy. I have here, thanks to the Brush Electric Engineering Company, an electromagnet of the special form that is used in the Brush arc lamp when required for the purpose of working in an alternating current circuit. It has two bobbins that are screwed up against the top of an iron box at the head of the lamp. The iron slab serves as a kind of yoke to carry the magnetism across the top. There are no fixed cores in the bobbins, which are entered by the ends of a pair of yoked plungers. Now in the ordinary Brush lamp for use with a steady current the plungers are simply two round pieces of iron tapped into a common yoke; but for alternate current working this construction must not be used, and instead a U-shaped double plunger is used, made up of laminated iron, riveted together. Of course it is no novelty to use a laminated core; that device, first used by Joule, and then by Cowper, has been repatented rather too often during the past 50 years to be considered as a recent invention.

The alternate rapid reversals of the magnetism in the magnetic field of an electromagnet, when excited by alternating electric currents, sets up eddy-currents in every piece of undivided metal within range. All frames, bobbin tubes, bobbin ends and the like must be most carefully slit, otherwise they will overheat. If a domestic flat-iron is placed on the top of the poles of a properly laminated electromagnet, supplied with alternating currents, the flat-iron is speedily heated up by the eddy-currents that are generated internally within it. The eddy-currents set up by induction in neighboring masses of metal, such as copper, give rise to many curious phenomena. For example, a copper disc or copper ring placed over the pole of a straight electromagnet so excited is violently repelled. These remarkable phenomena have been recently investigated by Professor Elihu Thomson, with whose beautiful and elaborate researches we have lately been made conversant in the pages of the technical journals. He rightly attributes many of the repulsion phenomena to the lag in phase of the alternating currents thus induced in the conducting metal. The electromagnetic inertia, or self-inductive property of the electric circuit, causes the currents to rise and fall later in time than the electromotive forces by which they are occasioned. In all such cases the impedance which the circuit offers is made up of two things—resistance and inductance. Both these causes tend to diminish the amount of current that flows, and the inductance also tends to delay the flow.

ELECTROMAGNETS FOR QUICKEST ACTION.

I have already mentioned Hughes' researches on the form of electromagnet best adapted for rapid signaling. I have also incidentally mentioned the fact that where rapidly varying currents are employed, the strength of the electric current that a given battery can yield is determined not so much by the resistance of the electric circuit, but by its electric inertia. It is not a very easy task to explain precisely what happens to an electric circuit when the current is turned on suddenly. The current does not suddenly rise to its full value, being retarded by inertia. The ordinary law of Ohm in its simple form no longer applies; one needs to apply that other law which bears the name of the law of Helmholtz, the use of which is to give us an expression, not for the final value of the current, but for its value at any short time, t, after the current has been turned on. The strength of the current after a lapse of a short time, t, cannot be calculated by the simple process of taking the electromotive force and dividing it by the resistance, as you would calculate steady currents.

In symbols, Helmholtz's law is:

$$i_t = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right)$$

In this formula i_t means the strength of the current after the lapse of a short time t; E is the electromotive force; R the resistance of the whole circuit; L its co-efficient of self-induction; and e the number 2.7183, which is the base of the Napierian logarithms. Let us look at this formula; in its general form it resembles Ohm's law, but with a new factor, namely, the expression contained within the brackets. This factor is necessarily a fractional quantity, for it consists of unity less a certain negative exponential, which we will presently further consider. If the factor within brackets is a quantity less than unity, that signifies that i_t will be less than $E \div R$. Now the exponential of negative sign, and with negative fractional index, is rather a troublesome thing to deal with in a popular lecture. Our best way is to calculate some values, and then plot it out as a curve. When once you have got it into the form of a curve, you can begin to think about it, for the curve gives you a mental picture of the facts that the long formula expresses in the abstract. Accordingly we will take the following case: Let $E = 10$ volts; $R = 1$ ohm; and let us take a relatively large self-induction, so as to exaggerate the effect; say let $L = 10$ quads. This gives us the following:

$t_{(sec)}$	$e^{+\frac{R}{L}t}$	i_t
0	1	0
1	1.105	0.950
2	1.221	1.810
5	1.649	3.936
10	2.718	6.343
20	7.389	8.646
30	20.08	9.501
60	403.4	9.975
120	162800.0	9.999

In this case the value of the steady current as calculated by Ohm's law is 10 ampères; but Helmholtz's law shows us that with the great self-induction, which we have assumed to be present, the current, even at the end of 30 seconds, has only risen up to within 95 per cent. of its final value; and only at the end of two minutes has practically attained full strength. These values are set out in the highest curve in Fig. 54, in which, however, the further supposition is made that the number of spirals S in the coils of the electromagnet is 100, so that when the current attains its full value of 10 ampères, the full magnetizing power will be $Si = 1{,}000$. It will be noticed that the curve

rises from zero at first steeply and nearly in a straight line, then bends over, and then becomes nearly straight again as it gradually rises to its limiting value. The first part of the curve—that relating to the strength of the current after a *very small* interval of time—is the period within which the strength of the current is governed by inertia (*i. e.*, the self-induction) rather than by resistance. In reality the current is not governed either by the self-induction or by the resistance alone, but by the ratio of the two. This ratio is sometimes called the "time-constant" of the circuit, for it represents *the time* which the current takes in that circuit to rise to a definite fraction of its final value. This definite fraction is the fraction $\frac{e-1}{e}$; or in decimals, 0.634. All curves of rise of current are alike in general shape—they differ only in scale; that is to say, they differ only in the height to which they will ultimately rise, and in the time they will take to attain this fraction of their final value.

Example (1).—Suppose $E = 10$; $R = 400$ ohms; $L = 8$. The final value of the current will be 0.025 ampères or 25 milliampères. Then the time-constant will be $8 \div 400 = 1\text{-}50\text{th}$ second.

Example (2).—The P. O. Standard "A" relay has $R = 400$ ohms; $L = 3.25$. It works with 0.5 milliampère current, and therefore will work with 5 Daniell cells through a line of 9,600 ohms. Under these circumstances the time-constant of the instrument on short circuit is 0.0081 second.

It will be noted that the time-constant of a circuit can be reduced either by diminishing the self-induction or by increasing the resistance. In Fig. 54 the position of the time-constant for the top curve is shown by the vertical dotted line at 10 seconds. The current will take 10 seconds to rise to 0.634 of its final value. This retardation of the rise of current is simply due to the presence of coils and electromagnets in the circuit; the current as it grows being retarded because it has to create magnetic fields in these coils, and so sets up opposing electromotive forces that prevent it from growing all at once to its full strength. Many electricians unacquainted with Helmholtz's law have been in the habit of accounting for this by saying that there is a lag in the iron of the electromagnet cores. They tell you that an iron core cannot be magnetized suddenly; that it takes time to acquire its magnetism. They think it is one of the properties of iron. But we know that the only true time-lag in the magnetization of iron—that which is properly termed "viscous hysteresis"—does not amount to three per cent. of the whole amount of magnetization, takes many minutes to show itself, and cannot therefore be the cause of the retardation which we are considering. There are also electricians who will tell you that when magnetization is suddenly evoked in an iron bar there are induction currents set up in the iron which oppose and delay its magnetization. That they oppose the magnetization is perfectly true; but if you carefully laminate the iron so as to eliminate eddy-currents, you will find, strangely enough, that the magnetism rises still more slowly to its final value. For by laminating the iron you have virtually increased the self-inductive action, and increased the time-constant of the circuit, so that the currents rise more slowly than before. The lag is not in the iron, but in the magnetizing current, and the current being retarded, the magnetization is, of course, retarded also.

CONNECTING COILS FOR QUICKEST ACTION.

Now let us apply those most important though rather intricate considerations to the practical problems of the quick working of the electromagnet. Take the case of an electromagnet forming some part of the receiving apparatus of a telegraph system, in which it is desired to secure very rapid working. Suppose the two coils that are wound upon the horseshoe core are connected together in series. The coefficient of self-induction for these two is four times as great as that of either separately; coefficients of self-induction being proportional to the square of the number of turns of wire that surround a given core. Now if the two coils, instead of being put in series, are put in parallel, the coefficient of self-induction will be reduced to the same value as if there were only one coil, because half the line current (which is practically unaltered) will go through each coil. Hence the time constant of the circuit when the coils are in parallel will be a quarter of that which it is when the coils are in series; on the other hand, for a given line current, the final magnetizing power of the two coils in parallel is only half what it would be with the coil in series. The two lower curves in Fig. 54 illustrate this, from which it is at once plain that the magnetizing power for very brief currents is greater when the two coils are put in parallel with one another than when they are joined in series.

Now this circumstance has been known for some time to telegraph engineers. It has been patented several times over. It has formed the theme of scientific papers which have been read both in France and in England. The explanation generally given of the advantage of uniting the coils in parallel is, I think, fallacious; namely, that the "extra currents" (*i. e.*, currents due to self-induction) set up in the two coils are induced in such directions as tend to help one another when the coils are in series, and to neutralize one another when they are in parallel. It is a fallacy, because in neither case do they neutralize one another. Whichever way the current flows to make the magnetism, it is opposed in the coils while the current is falling by the so-called extra currents. If the current is rising in both coils at the same moment, then, whether the coils are in series or in parallel, the effect of self-induction is to retard the rise of the current. The advantage of parallel grouping is simply that it reduces the time constant.

BATTERY GROUPING FOR QUICKEST ACTION.

One may consider the question of grouping the battery cells from the same point of view. How does the need for rapid working and the question of time-constant affect the best mode of grouping the battery cells? The amateur's rule, which tells you to so arrange your battery that its internal resistance should be equal to the external resistance, gives you a result wholly wrong for rapid working. The supposed best arrangement will not give you (at the expense even of economy) the best result that might be got out of the given number of cells. Let us take an example and calculate it out, and place the results graphically before our eyes in the form of curves. Suppose the line and electromagnet have together a resistance of six ohms, and that

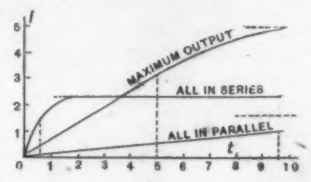


Fig. 55.—Curves of Rise of Current with Different Groupings of Battery.

we have 24 small Daniell's cells, each of electromotive force, say, one volt, and of internal resistance four ohms. Also let the coefficient of self-induction of the electromagnet and circuit be six quadrants. When all the cells are in series the resistance of the battery will be 96 ohms, the total resistance of the circuit 102 ohms, and the full value of the current 0.235 ampère. When all the cells are in parallel the resistance of the battery will be 0.133 ohm, the total resistance 6.133 ohms, and the full value of the current 0.162 ampère. According to the amateur rule of grouping cells so that internal resistance equals external, we must arrange the cells in four parallels, each having six cells in series, so that the internal resistance of the battery will be six ohms, total resistance of circuit 12 ohms, full value of current 0.5 ampère. Now the corresponding time-constants of the circuit in the three cases (calculated by dividing the coefficient of self-induction by the total resistance) will be respectively—in series, 0.06 sec.; in parallel, 0.96 sec.; grouped for maximum steady current, 0.5 sec. From these data we may now draw the three curves, as in Fig. 55, wherein the abscissæ are the values of time in seconds, and the ordinates the current. The faint vertical dotted lines mark the time-constants in the three cases. It will be seen that when rapid working is required the magnetizing current will rise, during short intervals of time, more rapidly if all the cells are put in series than it will do if the cells are grouped according to the amateur rule.

When they are all put in series, so that the battery has a much greater resistance than the rest of the circuit, the current rises much more rapidly, because of the smallness of the time-constant, although it never attains the same ultimate maximum as when grouped in the other way. That is to say, if there is self-induction as well as resistance in the circuit, the amateur rule does not tell you the best way of arranging the battery. There is another mode of

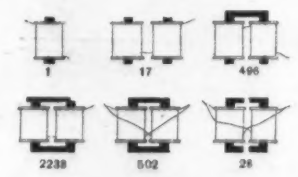


Fig. 56.—Electromagnets of Relay, and their Effects.

regarding the matter which is helpful. Self-induction, while the current is growing, acts as if there were a sort of spurious addition to the resistance of the circuit; and while the current is dying away it acts of course in the other way, as if there were a subtraction from the resistance. Therefore you ought to arrange the batteries so that the internal resistance is equal to the real resistance of the circuit, plus the spurious resistance during that time. But how much is the spurious resistance during that time? It is a resistance proportional to the time that has elapsed since the current was turned on. So then it comes to the question of the length of time for which you want to work it. What fraction of a second do you require your signal to be given in? What is the rate of the vibrator of your electric bell? Suppose you have settled that point, and that the short time during which the current is required to rise is called t; then the apparent resistance at time t after the current is turned on is given by the formula:

$$R_t = R \times e^{\frac{R}{L}t} + \left(e^{\frac{R}{L}t} - 1.\right)$$

TIME CONSTANTS OF ELECTROMAGNETS.

I may here refer to some determinations made by M. Vaschy,* respecting the coefficients of self-induction of the electromagnets of a number of pieces of telegraphic apparatus. Of these I must only quote one result, which is very significant; it relates to the electromagnet of a Morse receiver of the pattern habitually used on the French telegraph lines.

	L, in quadrants.
Bobbins, separately, without iron cores	0.233 and 0.265
Bobbins, separately, with iron cores	1.65 and 1.71
Bobbins, with cores joined by yoke, coils in series	6.37
Bobbins, with armature resting on poles	10.68

It is interesting to note how the perfecting of the magnetic circuit increases the self-induction.

Thanks to the kindness of your vice-president, Mr. Preece, I have been furnished with some most valuable information about the coefficients of self-induction, and the resistance of the standard pattern of relays and other instruments which are used in the British postal telegraph service, from which data one is able to say exactly what the time-constants of those instruments will be on a given circuit, and how long in their case the current will take to rise to any given fraction of its final value. Here let me refer to a very capital paper by Mr. Preece in an old number of the "Journal of the Society of Telegraph Engineers," a paper "On Shunts," in which he treats this question, not as perfectly as it could now be treated with the fuller knowledge we have in 1890 about the coefficients of self-induction, but in a very useful and practical way. He showed most completely that the more perfect the magnetic circuit is—though, of course, you are getting more magnetism from your current—the more is that current retarded. Mr. Preece's mode of experiment was extremely simple; he observed the throw of the galvanometer, when the circuit which contained the battery and the electromagnet was opened by a key which at the same moment connected the electromagnet wires to the galvanometer. The throw of the galvanometer was assumed to represent the extra current which flowed out. Fig. 56 represents a few of the results of Mr. Preece's paper. Take from an ordinary relay a coil, with its iron core, half the electromagnet, so to speak, without any yoke or armature. Connect it up as described, and observe the throw given to the galvanometer. The amount of throw obtained from the single coil was taken as unity, and all others were compared with it. If you join up two such coils as they are usually joined, in series, but without any iron yoke across the cores, the throw was 17. Putting the iron yoke across the cores, to constitute a horseshoe form, 496 was the throw; that is to say, the tendency of this electromagnet to retard the current was 496 times as great as that of the simple coil. But when an armature was put over the top the effect ran up to 2,238. By the mere device of putting the coils in parallel, instead of in series, the 2,238 came down to 502, a little less than the quarter value which would have been expected. Lastly, when the armature and yoke were both of them split in the middle, as is done in fact in all the standard patterns of the British Postal Telegraph relays, the throw of the galvanometer was brought down from 502 to 26. Relays so constructed will work excessively rapidly. Mr. Preece states that with the old pattern of relay having so much self-induction as to give a galvanometer throw of 1,688, the speed of signaling was only from 50 to 60 words per minute; whereas with the standard relays constructed on the new plan, the speed of signaling is from 400 to 450 words per minute. It is a very interesting and beautiful result to arrive at from the experimental study of these magnetic circuits.

SHORT CORES VERSUS LONG CORES.

In considering the forms that are best for rapid action, it ought to be mentioned that the effects of hysteresis in retarding changes in the magnetization of iron cores are much more noticeable in the case of nearly-closed magnetic circuits than in short pieces. Electromagnets with iron armatures in contact across their poles will retain, after the current has been cut off, a very large part of their magnetism, even if the cores be of the softest of iron. But so soon as the armature is wrenched off the magnetism disappears. An air gap in a magnetic circuit always tends to hasten demagnetizing. A magnetic circuit composed of a long air path and a short iron path demagnetizes itself much more rapidly than one composed of a short air path and a long iron path. In long pieces of iron the mutual actions of the various parts tend to keep in them any magnetization that they may possess; hence they are less readily demagnetized. In short pieces where these mutual actions are feeble, or almost absent, the magnetization is less stable and disappears almost instantly on the cessation of the magnetizing force. Short bits and small spheres of iron have no "magnetic memory." Hence the cause of the commonly-received opinion among telegraph engineers that for rapid work electromagnets must have short cores. As we have seen, the only reason for employing long cores is to afford the requisite length for winding the wire which is necessary for carrying the needful circulation of current to force the magnetism across the air-gaps. If, for the sake of rapidity of action, length has to be sacrificed, then the coils must be heaped up more thickly on the short cores. The electromagnets in American patterns of telegraphic apparatus usually have shorter cores and a relatively greater thickness of winding upon them than those of European patterns.

* "Bulletin de la Société Internationale des Electriciens," 1886.

The New Building of the Canadian Bell Telephone Company at Hamilton, Ont.

During the past year the business of the Bell Telephone Company in Canada has been increasing with such unwonted rapidity that it has been found necessary to erect new and more commodious quarters for the principal offices at Hamilton, Ont. It was decided last summer to make the change, and the contract for the new building was let in September last. At the present time great headway has already been made with the work. The new quarters are situated on the corner of Heugleson and Catherine streets, about a block from the present office, and the building is 170 feet in length by 43 feet deep, and three stories high. The situation is a most excellent one, overlooking the Court House Square, and being very close to the business centre of the city. The walls of the structure are of pressed brick with cut stone facings, and the entire building will be occupied by the telephone company. The ground floor will be used for the storage and shipping departments, while the second floor will contain the general offices, the office of the local manager and repair shop to the public trunk line.

The third floor will contain the operating room proper, the distributing room, battery and power room, etc. The operating room will be 99 × 21 feet, and is provided with seventeen large plate glass windows so that it will be exceptionally well lighted. In one corner is situated the private office of the manager of the exchange partitioned off from the rest of the room with glass so as to admit of a complete view of what is going on, and at the same time prevent intrusion. Just off the operating room is a distributing room

THE CANADIAN BELL TELEPHONE COMPANY'S NEW BUILDING AT HAMILTON ONT.

57 × 19 feet. In this there will be placed a distributing board of new design and the most perfect workmanship obtainable. The battery and power room, together with cloak room and closets, opens off the distributing room, and is furnished in the most careful and complete manner with everything necessary for the comfort of the employés and the proper care of the apparatus necessary for the work. All the wires will be carried underground for about a block from the building in either direction, and will enter the basement at the south end, and thence pass up a long shaft leading into the distributing room, where they will connect with the special switchboard before mentioned. The new switches placed in the operating room are on the multiple metallic circuit system, and are provided with tubular drops and the most recent improvements in arrangement to facilitate rapid and perfect work. At the present time the company has about 1,000 subscribers in the city, or one to every 50 inhabitants, but provision is being made for an ultimate capacity of 3,000 lines. Under the energetic management of the local manager, Mr. K. J. Dunstan, the service has increased with great rapidity, and there is every reason to believe that a large proportion of the full capacity will come into use very soon. Mr. H. C. Baker, general manager for the Ontario department and well known in telephone circles throughout the country, will have his general office on the second floor of the building. The new structure will be lighted throughout with incandescent lamps, and nothing has been left undone to make it as complete and finished a telephone station as can be found on the continent. The building itself is a beautiful one, and the Canadian Bell Telephone Company is certainly to be congratulated on its taste as well as on the fast growing business which has necessitated such an elegant addition to its present accommodations.

Electrical Progress in Seattle, Wash.

Electrical matters in Seattle seem to be in touch with everything else in that remarkable city. The electric lighting and the electric railway companies seem to be unable to keep up with the demand for their products. The history of the Home Electric Company shows a growth as phenomenal as the growth of the city. February 25 of this year an electric light franchise was granted by the city to Edward C. Kilbourne, who immediately formed the Pacific Electric Light Company, and in 65 days a plant had been put up, and was furnishing current for 500 incandescent lights, and a few days later was supplying arc lights and power for motors. An all-day service was inaugurated June 1. The plant was started with a capacity for 1,300 alternating current incandescent lights, of the Thomson-Houston system, and 50 arc lights, and a 30,000-watt Mather generator for motors was put in place.

June 1 the company added a 650-light incandescent machine for the day service, and July 1 50 more arc lights were added. In August a combination was effected with the Commercial Electric Light Company, having 1,500 Westinghouse incandescent lights and 105 Waterhouse arc lights, and Sept. 1 both plants were transferred to the consolidated company, known as the Home Electric Company. Both stations are now running to their fullest capacity.

The Home Electric Company purchased in October lots on the corner of Sixth and Olive streets. Three days later grading was begun, and the company now has nearly completed a brick building 120 feet square and two stories high, in which it will place six return tubular boilers 72 inches by 18 feet, and three 200 h. p. and two 150 h. p. compound Armington & Sims engines. To this station will be transferred all the dynamos from the other two stations, and 2,600 incandescent lights and 100 arcs will be added, making the total capacity of the station 6,050 incandescent and 305 arc lights, besides the power generator The Pond Engineering Company, of Seattle, is putting in the power plant.

The dynamo and engine-room of the new station will be 60 × 120 feet, and boiler room will be of the same size. Coal will be hauled in by the Seattle Electric Railway Company, and dumped directly from the cars into the bunkers back of the boiler. Soon after the completion of the above plant the company expects to begin work on the installation of six more boilers, and 1,000 more h. p. of engines, hoping to be able to supply the demand for lights during the winter of 1891 and 1892. The officers of the Home Electric Company are: Isaac Dobson, president; E. C. Kilbourne, vice-president and general manager; D. B. Denton, treasurer; A. C. Balch, secretary and electrical engineer.

The Proposed Pacific Cable.

The project of connecting Australia with Canada by a cable across the Pacific Ocean, according to an Ottawa correspondent of the New York *Times*, has now been before the public about ten years, having been first suggested by Mr. Sandford Fleming in the report submitted to the Dominion Parliament in 1880. As a practical question, however, the history of the scheme may be said to date from 1887, when a conference of delegates from various parts of the British empire was held in London. At this meeting the plan was fully explained by the delegates from Canada—Mr. Sandford Fleming and Sir Alexander Campbell—and aroused a great, and for the most part a friendly, interest. At the same meeting there was also revealed the fact that the project had a strong opponent in the Eastern and Eastern extension which now control the telegraphic communication between Australia and Great Britain and enjoy a monopoly which would be destroyed if telegrams could be sent across the Atlantic, then through Canada, and then across the Pacific Ocean to Australasia. The conference adopted a resolution declaring "that the connection of Canada with Australasia by a direct submarine telegraph across the Pacific is a project of high importance to the empire, and every doubt as to its practicability should, without delay, be set at rest by a thorough and exhaustive survey." The favor with which the idea was received appears to have alarmed the existing companies, for last summer they endeavored to make an arrangement which would have given their monopoly a new lease of life. They offer to reduce their cable rates one-half on condition that the governments interested would give a guarantee equivalent to about £54,000 a year. The Australian colonies were willing to enter into this arrangement, but Great Britain and New Zealand declined to share in the guarantee, and there the matter stands to-day. In the meantime Mr. Sandford Fleming took the opportunity to explain the Pacific plan. It was contended by Mr. Fleming that the guarantee asked for in consideration of the reduction of the rates of the old company, namely, £54,000 a year, would be equal to the annual charge upon the capital required for the construction of a cable from Canada to Australia. The length of the cable necessary to stretch across the Pacific from Canada to New Zealand and Australia is estimated by competent authorities at 8,900 miles, and Mr. Fleming says that the outside cost of a cable of the very best sort would be £1,800,000. Three per cent. upon this sum would amount to £54,000 a year. It is further pointed out that the building of the Canadian line would reduce the cost of messages from England to Australia to one-fourth what they are now, while the proposal of the existing companies is to reduce them by only one-half. The length of the line is not so formidable an obstacle to the success of the project as may at first sight appear, for owing to the presence of a number of stations in the Pacific the longest stretch would be about 2,700 miles, the others ranging from 1,200 miles upward.

Efficiency of a Combined Engine and Dynamo.

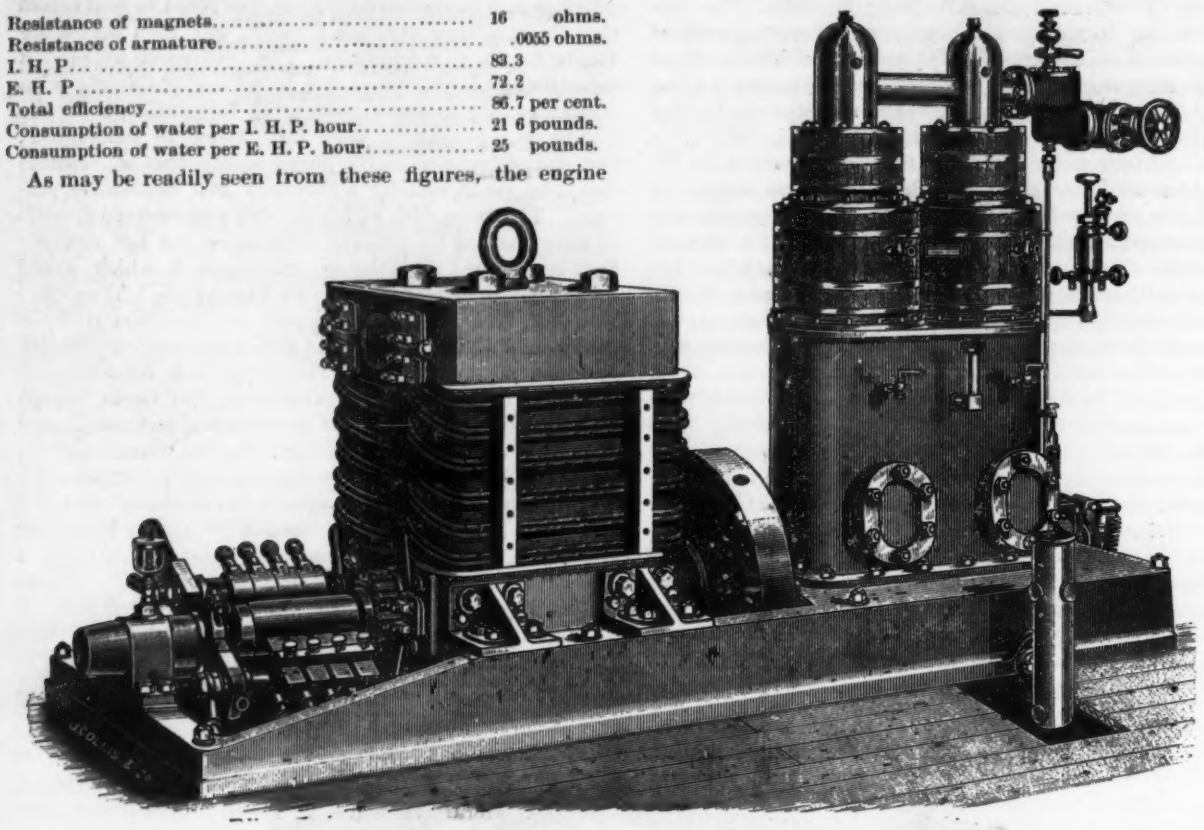
The direct union of engine and dynamo on a single base is rather growing in frequency. The exigencies of ship lighting have created a demand for such machines, and as the average speed of dynamos has greatly fallen, owing to improved construction, the direct coupled machine is coming into more and more prominence. Some interesting tests have recently been made in England with a direct coupled machine of the Edison-Hopkinson type, driven by a compound double-crank engine made by Willan & Robinson. The results of the test show an efficiency of engine and dynamo that is emphatically remarkable, and distinctly greater than any similar result which has heretofore been reported.

The particulars of the engine and dynamo are as follows: The engine is a double cylinder compound, with low pressure cylinder 14 inches in diameter and 16 inches stroke, working with 120 pounds of steam pressure. It is coupled to a dynamo constructed for an output of 475 ampères at 110 volts when driven at 430 revolutions per minute. The

armature is of the bar construction, is plain shunt wound, and is fitted with a commutator of hard drawn copper with mica insulation. Four brushes are carried on each rocker arm. Some details of the machine and its performance are as follows:

Resistance of magnets	16 ohms.
Resistance of armature	.0055 ohms.
I. H. P.	83.3
E. H. P.	72.2
Total efficiency	86.7 per cent.
Consumption of water per I. H. P. hour	21 6 pounds.
Consumption of water per E. H. P. hour	25 pounds.

As may be readily seen from these figures, the engine and dynamo were worked above their full normal output, which fact would tend to slightly increase the efficiency.



EDISON-HOPKINSON DYNAMO COUPLED DIRECT TO A WILLAN ENGINE.

Another test made with a precisely similar combination, working at its normal load, gave the following results:

Resistance of armature	.0058 ohms.
Resistance of magnets	15.6 ohms.
I. H. P.	85.3
E. H. P.	70.
Giving a total efficiency of	83.3 per cent.

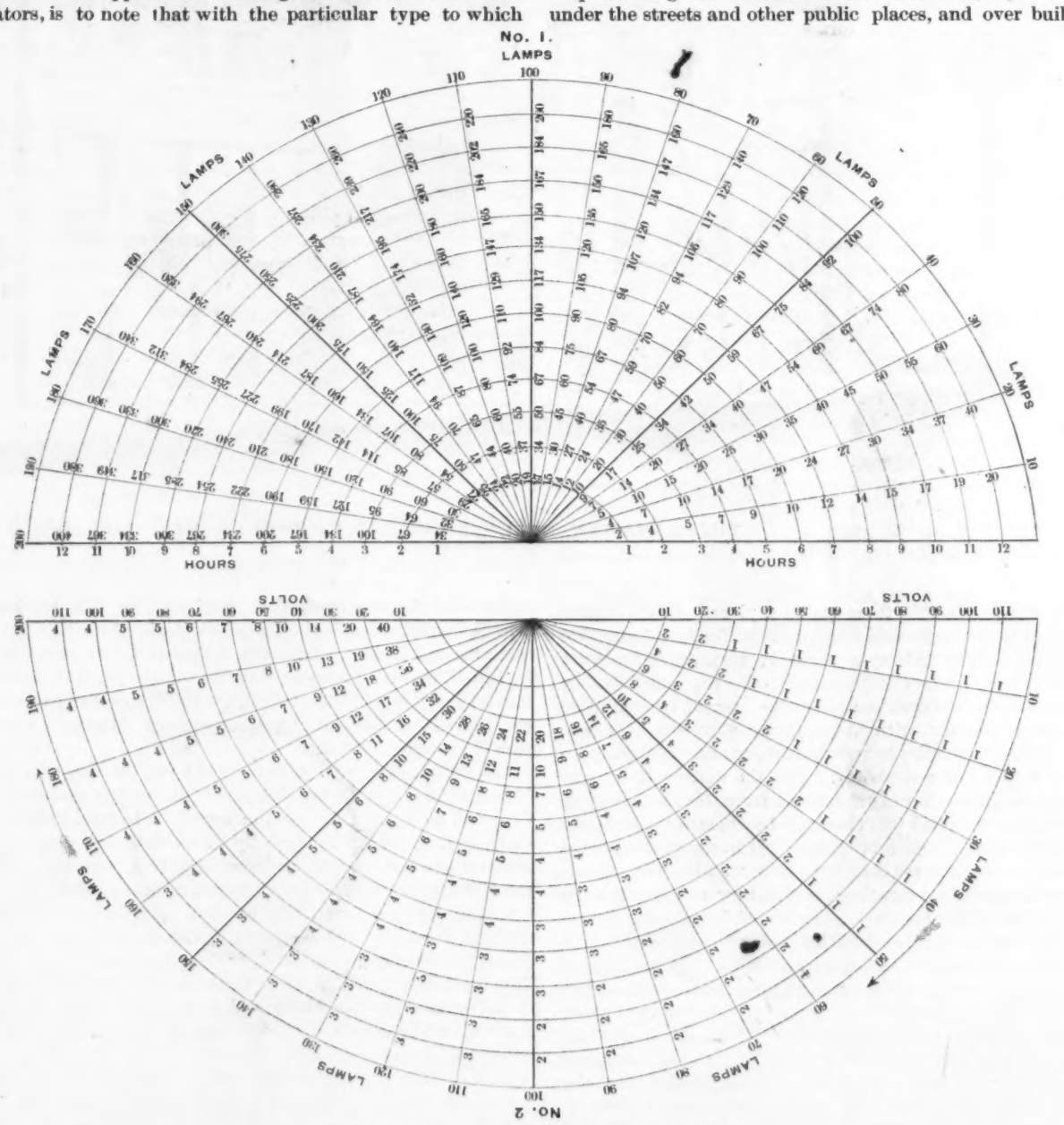
In the first experiment the electrical losses were as follows: Loss in magnet coils, 756 watts, equal to 1.4 per cent.; loss in armature coil, 1,386 watts, equal to 2.6 per cent., so that the electrical efficiency of the machine due to ohmic resistance alone was 96 per cent. The remainder of the losses, a little over 8 h. p., is due to friction of engine and dynamo, hysteresis and the like. This is certainly an admirable showing, both for the engine and dynamo, for, not only must the latter be more than usually efficient, but the former must be singularly light running, to give so small an amount of friction. Messrs. Mather & Platt, builders of the dynamo, have constructed a large number of similar combinations. Those referred to are part of a considerable order made for ordinary electric light service.

Calculating Storage Battery Plants.

The accompanying diagram gives a convenient short cut to computing the number of accumulators necessary to run any given number of incandescent lamps. It has been devised by the Consolidated Electric Storage Company with special reference to a standard type of cell, their S17. The S17 cell is the standard size made for general lighting and traction work. It has a nominal capacity of 180 ampère hours at a 10-ampère discharge rate, but which actual capacity considerably exceeds this under favorable circumstances. Its maximum rate of charge is 15 ampères; its maximum rate of discharge 20 ampères. It occupies floor space 7 × 8 inches, is 10 inches high, and weighs, complete, 42 pounds in a glass jar, or 35 pounds in a lighter rubber jar.

The tables give a rough approximation to the number of accumulators required, whatever the make, provided the type is equivalent to the one just described. The upper half of the diagram enables one to tell at a glance the number of accumulators required to operate any number of lamps up to 200 any number of hours from one to twelve. For example: Suppose we want to run 120 lamps nine hours per night; glance along the list of hours and follow the circle marked "9" around until it cuts the radius corresponding to the number of lamps; we see that 180 accumulators are required. But how shall they be arranged? This evidently depends on the voltage of the lamp. A 55-volt lamp would require only half as many accumulators in series as a 110-volt lamp. The lower half of the diagram, No. 2, gives an instantaneous means for ascertaining this. It shows the number of series which must be placed in parallel to make up the total number of accumulators; for example: suppose the 120 lamps just mentioned were to be 110-volt lamps; follow the voltage circle corresponding to 110 around until it cuts the radius corresponding to 120 lamps, and we find figure 3. This means that we are to have three series of accumulators in parallel, and since 180 cells were required in all we shall have 60 accumulators in series, and three such series coupled in parallel.

It should be understood that in case No. 2 of the diagram should give a number of series which does not contain the integral a number of times in the total number of accumulators, enough should be added to fill the requisite number of series up to the even amount. In other words, if there should be a remainder, on dividing, enough accumulators should be added to bring this remainder up to the same amount as the other series. Another way of getting at this same approximate arrangement for these accumulators, is to note that with the particular type to which this diagram applies the number of series equals the number of lamp hours divided by three times the proposed voltage of the lamp; for example: our 120 lamps operating 9 hours give 1,080 lamp hours. Dividing by three times the voltage (330), we find that there must be three series. The total number of cells required is then obtained by multiplying the number of series by one-half the voltage. In this case, three being the number of series, and the voltage, as before, being taken as 110, we should have three times 55, or 165 accumulators. It will thus be seen that while the figures given are only approximate, they agree fairly well with each other, and give an almost instantaneous method of estimating the number of accumulators required in a given case. The accumulator s known practically to so few people that this method of ready reckoning ought to prove very convenient.



BRACKEN'S ACCUMULATOR DIAGRAM.

Inspection of Electric Wires in Boston.

The Common Council has passed the following ordinance bearing on the supervision of electric wires throughout the city of Boston:

Section 1. A department of the city, to be known as the "department for the inspection of wires," and to be under the charge of the inspector of wires, is hereby created. Said inspector shall be appointed by the mayor, subject to confirmation by the board of aldermen, for the term of one year, beginning with the first day of May in the year of his appointment, and until his successor is appointed and confirmed, and shall be paid an annual salary at the rate of $3,500 a year.

Sec. 2. Said inspector shall supervise every wire or cable over streets or buildings, and every wire within a building, when such wire is designed to carry an electric light or power current; shall notify the person or corporation owning or operating any such wire or cable, whenever its attachments, insulation, supports or appliances are unsuitable or unsafe, or any tags or marks thereof, hereinafter described, are insufficient or illegible; and shall remove every wire abandoned for use and every wire, except the wire of a street railway company used for the transmission of its motive power, or for the protection or support of such wires, which, after the expiration of six months from the date of his appointment, shall be unprovided with a tag or mark distinctly designating the owner or user of such wire or cable; shall see that all statutes, ordinances and regulations relating to said duties, and to the location and removal of wires and cables in, over or under streets or buildings are strictly complied with and enforced.

Sec. 3. Said inspector shall, as soon as convenient after his appointment, make, and thereafter keep in his office, a map showing the location of all wires over, in, or laid under the streets and other public places, and over buildings of the said city, and a record of the names of the owner or owners of each and all said wires.

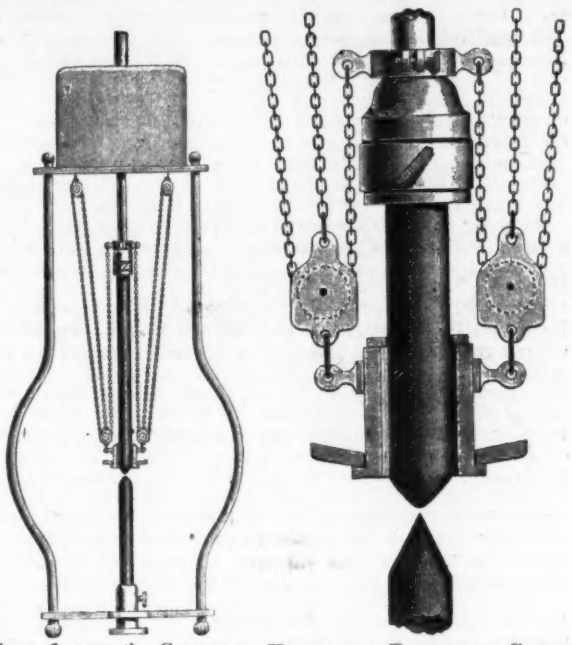
Sec. 4. Said inspector shall, when so required by the mayor or aldermen, examine every application for the erection of any wire, or poles or posts for the support thereof, in or over any street or public place, or for conduits under any street or public place for such wire, and shall report to them any facts which, in his opinion, bear upon the question of granting or refusing to grant such application.

Sec. 5. Said inspector shall have the charge and con-

trol of the erection and maintenance of all wires owned by the city, including the fire alarm telegraph and police electric signal and telephone systems, and of the posts and other supports therefor now erected or owned, or hereafter erected by the city. He shall purchase and set up all the wires, posts, supports, and all the dynamos, machinery and other electrical appliances required by the city in all departments, and shall see that all the said wires, posts, machinery and appliances are maintained and kept at all times in good order and condition.

The Hazeltine Carbon Protector.

We give below some details of a very interesting recent invention intended for the purpose of preventing the lateral waste which is so formidable a factor in the wear-



FIGS. 1 AND 2.—GENERAL VIEW AND DETAIL OF CARBON PROTECTOR.

ing out of carbon pencils in arc lamps. The destruction of the carbon in practice is partially due to actual waste at the point where the arc forms, and still more is produced by wasting around the sides of the poles where no proper return for the destruction is made in light received.

Fig. 1 shows the general arrangement of the apparatus. It consists of a snugly fitting collar, made of fire clay or some similar refractory material, embracing the upper or positive carbon just above its point, and kept in the same position relative to the arc by the arrangement of chains shown in the figure.

Fig. 2 shows the protector in detail. It shields the upper carbon so that the arc has no chance to disintegrate the carbon except at the immediate point where the arc is formed. The result of this protective action is admirably shown in Fig. 3, which exhibits two positive carbons burned respectively with and without the shield on an ordinary

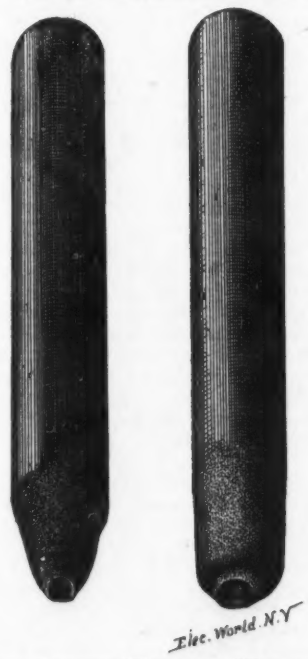


FIG. 3.—CARBONS BURNED WITH AND WITHOUT THE HAZELTINE PROTECTOR.

high tension circuit. It will be seen that one of these has a very blunt point with a wide shallow crater and shows almost no lateral waste, while the other burned without the shield has a rather tapering point of the ordinary form with a crater deep and of small diameter. A glance would suggest that the shield is likely to increase the life of the carbon, and experience has shown that such is the case, for a carbon which will burn eight hours in ordinary use will last nearly 16 hours when used with the shield. The device has already been in use by the Municipal Electric Lighting and Power Company, of St. Louis, and the saving in the cost of carbons, trimming and caring for lamps is reported not less than 50 per cent. It is stated, too, that the effective candle power of the lamp is apparently increased, but whether or not this is the case the carbon protector certainly serves a useful purpose in prolonging the life of the carbons. The Hazeltine Electric Company, of St. Louis, which manufactures the protector, is making arrangements to put it into extensive use, so that the claims which have been made for its economy will soon be tested on a large scale. A simple inspection of the form of carbon point produced by its use is sufficient to show the general result which has been obtained.

The Bradner Adjustable Lamp Hanger.

We give herewith a cut of a convenient device for incandescent lighting which is being brought prominently before the public by the McCreary Electrical Specialty

ADJUSTABLE LAMP HANGER.

Company, of New York. It is the Bradner adjustable hanger, and, as will be seen, is intended to enable an incandescent lamp to be adjusted to exactly the point where it is most convenient. The apparatus consists of a suspended differential pulley inclosed in a brass shield. A flexible cord is wound several times around the larger drum within the shell, passed through an opening and then around the smaller drum, and the lamp and shade being perfectly balanced by the weight of the pulley, the lamp will remain in any position.

Should a lamp and fixtures be heavier than the pulley there are weights provided, fitting a recess in the pulley, so that the balance will be perfect and the adjustment of the lamp to any position entirely easy throughout.

The Suspended Coil in Cable Work.*

BY E. RAYMOND BARKER.

In 1887 I was engaged in experimenting at Madeira with a view to arrange a mirror suspension which, while sufficiently heavy and sluggish to be unaffected by jerky vibra-

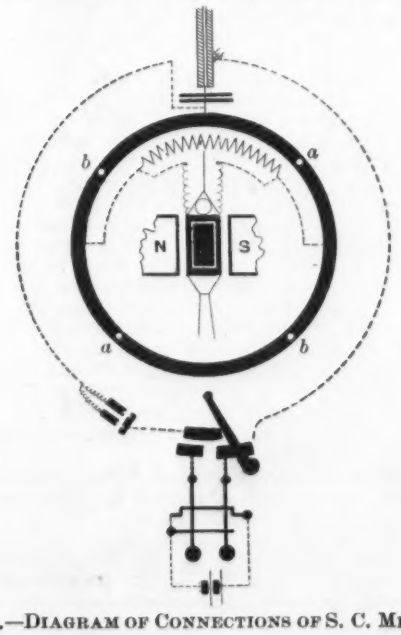


FIG. 1.—DIAGRAM OF CONNECTIONS OF S. C. MIRRORS.

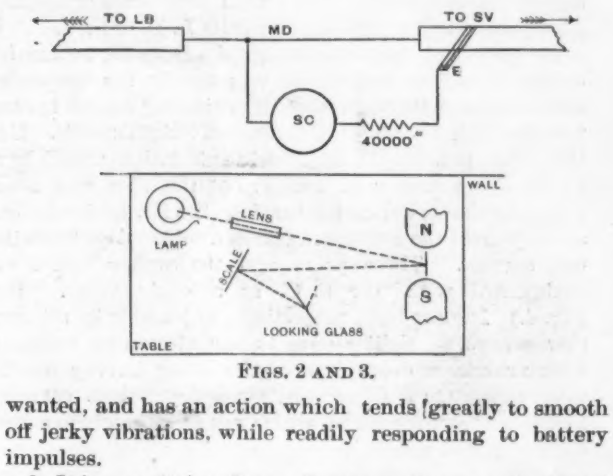
tions, due to gas bubbles from a troublesome cable fault, would be sensitive enough to give fair signals in response to firm manipulation of the distant station's key. I was endeavoring, in short, to evolve an instrument sympathetic to firmly transmitted signals, but the reverse to sudden vibrations arising from a fault. A brief account of the experiments and the results achieved may not be uninteresting or uninstructive.

*From *The Electrician*, London.

Tiny Thomson mirrors, with short, delicate suspensions, we found far too sensitive to vibratory influences, although they gave capital signals when the fault happened to be quiet, which was but seldom. It is interesting to watch the behavior of a fault. There is, first of all, a slight but almost constant vibration of the "spot," which, however, scarcely interferes with signaling. The same cannot be said of what follows. The slight vibration dies away, while the signals rapidly increase in size and clearness, when, suddenly, the emission of a gas bubble at the fault gives a violent jerk to the "spot," which again settles down with a shiver most bewildering to the mirror reader.

Unfortunately for the experiments (*pace* B. S. T. C.!), the fault was cut out before we could give a thorough trial to a new arrangement, which consisted of a long-range mirror on a 500ω coil, the latter hung between the poles of a strong permanent magnet, and kept in position by fibres and weights, as in Thomson's recorder. Experiments, however, show that—

1. This instrument approaches very near to what is



FIGS. 2 AND 3.

wanted, and has an action which tends greatly to smooth off jerky vibrations, while readily responding to battery impulses.

2. It is a capital "all-round" mirror, for one adjustment suffices for signals from cables of very unequal lengths. The Madeira-St. Vincent sections of the Brazilian Submarine Company's cables are roughly twice the electrical length of the Madeira-Lisbon; yet the suspended-coil mirror answers equally well on all, without alteration of suspension.

3. Notwithstanding the great comparative weight of coil and mirror, and the general stiffness and rigidity imparted to the signals by the lower bifilar suspension and weights, the instrument, as a signaling mirror, is more sensitive than the Thomson.

4. In a test comparing a Thomson long-cable mirror of 3,000ω, with a S. C. mirror of 500ω, range of mirrors being one metre, the current giving one division on test scale, for Thomson's mirror was .0017 milliampère and for S. C. mirror .00089 milliampère. That is to say, the S. C. mirror is roughly twice as sensitive as Thomson's. The instruments were tested just as they stood, and both might have been more sensitive.

Such sensitiveness as that here shown is certainly not necessary. In fact, for mirror signaling, nothing could be superior to the Thomson, which, simple, sensitive, and

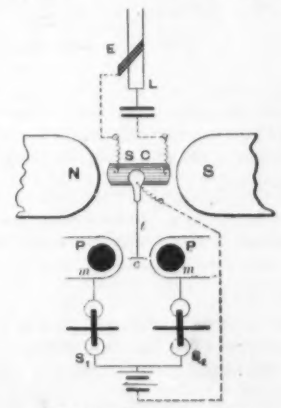


FIG. 4.—S. C. RELAY.

portable, is an ideal instrument. The writer only wishes to show what the S. C. mirror is capable of, and the advantages attaching to its use under certain conditions.

Fig. 1 shows connections of our S. C. mirror. They are made to give sending signals as a check on key and battery. There are two low-resistance shunts adjusting out-going signals to high and low battery powers. The poles and coil protrude upward through the table, a small glazed aperture in wooden cover permitting projection of the "spot" in a radius lengthways with the table. Reading can be carried on either from scale or from the wall opposite to the clerk, as he sits square with the table. In the latter case, the mirror throws the "spot" on to a looking-glass, where it is again projected at right angles on to the wall. Also a large convex lens may be used, which gives a "spot" one foot high, read with ease from the far end of the room. The signals on wall being reversed to what they are on scale, the coil and receiving-shunt are joined through a reverser which alters direction of current at will. There is also a sloping desk, supporting a message pad, on to which the "spot" can be thrown for self-writing, which is further facilitated by the "spot" being projected, at will, across the entire pad. This instrument would be excellent for a "leak" station, which breaks in at intervals, and adjusts sending and receiving condi-

tions to varying lengths of cable and number of stations in circuit, and where one reliable permanent mirror is required, and nothing more.

In the Brazilian Submarine Company the mirror is now of the past and the recorder is universal. Last year, however, occasion offered a new experience with the S. C. mirror. A week's experiments were made for through working between St. Vincent and Lisbon (Carcavellos) with a leak of about 40,000 ohms at Madeira. In leak circuit, Madeira (M. D.) had an S. C. mirror as in Fig. 2.

With St. Vincent (S. V.) sending, a Thomson mirror with ordinary suspension showed the slightest perceptible movement, but no readable signals. The Lisbon (L. B.) signals were plain with S. C. mirror substituted. Signals from S. V. were perfectly readable, while with L. B. sending, S. C. had to be heavily shunted with key pressed down or raised, according as S. V. or L. B. transmitted. Signals from L. B. being, of course, reversed to those from S. V., we arranged, as in Fig. 3, signals, which as seen on the reflection of scale in the looking-glass, were reversed to real signals on scale itself. So we read from scale or looking-glass, according as signals come from L. B. or S. V.

Ten years ago the writer designed a relay for submarine cables of medium length. It was merely the suspended coil in a magnetic field with a projecting tongue to close two local circuits after the manner of Bright's bells. Had this been practicable, automatic translation would have followed as a matter of course; but the idea was abandoned by the writer on his hearing that Mr. De Sauty had already tried the suspended coil as a cable relay, but without success. Three years ago the writer again experimented with the S. C. as a cable relay. (See Fig. 4.) *P P* are brass projections, adjustable by micrometer screws, at right angles to the aluminum tongue *t*, which carrier a cross-piece *c*, the latter having needle-point ends. On *P P* are platinized depressions carrying globules of mercury *m m*, which act as contacts on both sides of *c*, and which, by capillary elevation, stand well above the surrounding brass, thus permitting *c* to swing against them free of *P P*. + and — impulse, through *S C*, cause corresponding contacts between *c* and *m m*, which bring into local circuits the sounders S^1 S^2, which, differing in tone, can be easily read.

Experiment showed that although with customary battery and condensers it was possible to receive distinct words through our Madeira-Lisbon sections, yet with anything approaching to fast working, make-and-break between *c* and *m m* could not be relied on, even with anti-speaking devices between *c* and *m m*. With St. Vincent sending at ordinary speed we obtained only confused beats on the sounders, without any perfect signals, it being impossible to adjust *m m* to the varying zero on this comparatively long cable. As an alarum relay, however, this instrument would work anything, from a bell to a mid-day gun or timeball.

Electric Welding Applied to the Manufacture of Projectiles.*

I am asked to-night to tell you something of a new process which has been originated and developed within the past year; a new and important application of an art in itself new, electric welding.

At this moment when there is so general an interest manifested throughout the country in the question of the nation's arms and defenses, this new invention, which bids fair to supersede and immensely cheapen existing methods, is sure to claim its share of attention, both from experts in ordnance and the general public.

Before entering upon the subject proper, I wish to say a few words on the general state of military art and on the production of projectiles in particular. For nearly a generation we have stood aside and watched others pass us in the race, forgetting what we knew so well at the close of our late war, until now we have finally awakened to find ourselves relegated to almost the lowest place among the nations of the earth. To use a lower simile, we might have been until very recently likened to a crab which has just shed its shell; rich and fat, but helpless—unable to assert our rights or aid our friends in time of need.

Since the earliest times man's ingenuity has been taxed, first to improve his weapons, next his defenses. The race between projectiles and armor commenced with the bow and arrow or sling as against the rawhide covered buckler. It has passed by gradual evolution through an infinite number of stages; sometimes the armor, sometimes the projectile ahead; generally the latter. Indeed, at times the projectile has been so much ahead as to cause the total abandonment of armor. This happened when the bullets and slugs from the crude blunderbuss of the middle ages made the matchless armor of the warrior of the day worse than useless. Some authorities are inclined to believe that an analogous case exists now, and that on the sea, at least, it is folly to burden vessels with an enormous weight of armor, which can be pierced so easily by the heavy projectiles thrown by the enormous high powered guns in use. To the casual observer this may seem true, but on the other hand, we must not forget that armor *does* protect against the great number of moderate size projectiles, and that if you can even only partially protect the vitals of your structure, it is much gained. We must also remember that these latest developments of armor and projectile have never been pitted against each other in actual warfare, and that there will be a vast difference between firing through a target at point blank range and at a swiftly moving, rolling, wavering object a mile or more away, which is at the same time firing back at you.

At the present moment it looks as though the projectile was about to gain another point over armor and become a still more important factor. Artillerists on shore are now directing their attention largely to the use of breech loading rifled howitzers or mortars. These guns are fired at a great elevation, rarely less than 45 degrees and frequently at 60 degrees. The projectile has, consequently, a high curved trajectory and plunges down on and through the decks of vessels or behind parapets. The decks of men-of-war are frequently not protected at all, except over the engines, boilers and magazines, where a curved armored deck is used with a maximum thickness of from four inches to six inches. Four inches is the greatest thickness of the curved protective decks of our new cruisers and is the only armor those now afloat have.

The varying ranges of these howitzer-thrown projectiles are given by increasing or decreasing the weight of the powder charge.

In some recent experiments made by Krupp, in Germany, very satisfactory results have been obtained by projectiles thrown from this class of gun against horizontal targets representing the armored decks of ships.

The defenses of Boston and our other seaboard cities are to comprise a large number of guns of this class. They fire both armor-piercing and common shell. Redoubts and turrets on shore can be armored as heavily as you please, or guns and troops can be defended by that most excellent protection, the earthwork. Afloat, however, where every pound carried is a matter of serious consideration, the problem is a very different one and the weight of armor must necessarily be limited by the size of the vessel. A proper navy, however, will always be made up of a number of vessels of various kinds, more or less dependent on each other, from the gigantic battle ship fully protected by the heaviest armor down; including the partially protected cruisers, fast unprotected vessels, dispatch boats, converted merchantmen used as commerce destroyers or transports, torpedo boats, etc.

Troops in the field are, like the unarmored cruisers, torpedo boats and converted merchantmen, practically unprotected.

For use against these various defenses and where there are no defenses except distance and advantage of position there are in use three general classes of projectiles (not considering the more or less experimental dynamite and other high explosive shells). They are, 1st, the armor-piercing shell, used solely, as its name indicates, against heavy armor; 2d, common shell, used against unprotected vessels and troops, for bombarding cities and earthworks, for target practice, etc.; 3d, shrapnel, so named from its inventor, extensively used in field operations on shore against bodies of troops and at sea against open boats, torpedo boats or any unprotected body of men.

Leaving the ordinary bullet of the shoulder rifle out of the question, these projectiles range in weight from those of a single pound to the gigantic missiles of the 110-ton gun, which weigh about one ton and are driven by almost half a ton of powder.

Now in order to show how much is gained in the construction of projectiles by the Thomson electric welding process, I will briefly describe the present methods of manufacture.

1st. The armor-piercing shell. To fulfill the government requirements these must be made of a fine quality of steel, capable of being made very hard and still be tough. In the first operation it is forged or rolled into a rough solid blank. After this it is placed in a lathe and turned off accurately on the outside and the powder chamber bored in the axis of the shell from the base, as in this specimen. This opening is then closed by a carefully-fitted screw plug, in the centre of which is a smaller threaded hole into which fits the percussion fuse which explodes the shell on impact. A groove is now turned in the outside near the base and knurled or roughened. This is for the copper rotating band, and the roughening is to prevent its slipping when the copper enters the rifling of the gun. Next the shell is hardened by one of the various processes which are more or less satisfactory, and finally the copper band is forced into place by hammering or hydraulic pressure and turned off true to gauge. This completes the projectile and you will readily understand that all this work is slow, tedious and expensive. Any one who is familiar with the operation of machining high carbon or tool steel will appreciate this. As a matter of fact, a 6-inch armor-piercing shell which only weighs 94 pounds costs in the neighborhood of $65 or $70.

Next come common shell. These at present are cast either of steel or iron, but even in this cheap form of production many difficulties are met with. In the first place, the shell usually has but one small opening to the inside powder chamber, and this only allows the use of a single "print" to hold up the core which forms the interior cavity, consequently, when the molten metal flows in it pushes this core out of place, and the resultant casting is eccentric—thin on one side, thick on the other—frequently so much so as to cause it to be discarded entirely. When the castings are received from the foundry they are first carefully calipered on the inside by a skilled operator, who uses a delicate instrument called a "star gauge," which expands within and enables him to determine the amount the casting is out of true, which he marks on the shell. It is then passed to the hands of the machinist. He is obliged to place it in his lathe eccentrically, so that the outside will be turned true with the inside; and you can imagine that even after all this care they are never perfectly concentric. Another serious difficulty met with in the cast projectiles is the liability to small blow holes or porosity, which, though they sometimes escape detection, always cause the rejection of the projectile when discovered. Through these holes the gases of the charge might be driven and thus cause a premature explosion of the shell in the gun. Steel shell of this description, of 6-inch calibre, cost about $30 each. Like the armor-piercing shell, they are fitted with rotating bands and fuses, but are not hardened.

We now come to the shrapnel. It was originally invented for use in the smooth-bore guns of the past and was then a hollow sphere filled with small bullets, around which was poured melted sulphur as a matrix. A small powder chamber for a bursting charge was left in the middle. It was provided with a time fuse which could be set so that the shell would explode at the desired moment in its flight, scattering its contents and fragments in the face of the enemy. So far, there seems to have been no very satisfactory shrapnel made for rifle guns. The difficulty is that the head or base has to be screwed on after the body of the shell has been filled with bullets and matrix. This construction weakens the projectile very much at this point, and the head or base is apt to blow out without bursting the body of the shell or scattering the bullets, especially as the walls of the projectile have to be made thick enough to stand the threading.

Hoping I have now made clear the general state of the art, I will explain wherein this new process differs, and will endeavor to illustrate it by the specimens I have here.

First, instead of the solid, rough-forged ingot, we have these three component parts, which when welded together will form a 6-pound armor-piercing shell. Each piece is now finished to exact size, except that there is a little extra length to allow for the take-up in welding. The head and base pieces are forged in dies to shape; the central portion is simply a piece cut from a length of solid drawn steel piping. It has all the additional strength due to the fibrous skin inside and out caused by the drawing process. To join these three pieces, they are clamped into a form of electric welding machine designed for the purpose, and in less than a minute are joined together and made a homogeneous mass like this.

It now only remains to grind off two burrs which you see in this specimen, and cut in the groove for the rotating band. The front one of these burrs may be used to form an enlargement used in many forms of projectiles, called technically, a "bourillet." It supports the front portion of the shell in the bore of a gun, the remainder not touching except at the rotating band. The other burr may be removed at the same time the rotating band groove is cut. The fuse hole has already been cut and threaded in the base piece. The shell is now ready for the hardening process. I wish to call attention here to the fact that the burrs are allowed to remain on the inside and thus form strengthening ribs which help materially to support the shell against the great crushing strain it receives on impact. You will see that we have thus formed a stronger and better shell with minimum of labor on the individual parts and a few seconds' work to join them together.

In order to illustrate the wonderful strength that may be gained by this welding process, I have here a shell which was constructed exactly as I have shown. It was fired through a 3-inch plate of iron at the naval proving grounds, at Annapolis, recently. You will see that it has not changed its shape in the slightest degree, nor has it even lost the copper rotating band which was carried through the hole with it. Here is another which shows a still more remarkable result. This projectile was fired against heavy steel armor which has a resistance of about 75 per cent. more than iron, and which was much heavier than a projectile of this size could be expected to perforate. It, however, penetrated 5 inches, and then owing to the elasticity of the oak backing of the plate, was thrown back about 30 feet, as perfect in condition as before it was fired from the gun. The experience of the Welding Company has been that the metal seems to be strengthened at the point of welding, and this certainly seems to justify the supposition.

After accomplishing results like this, you will see that the manufacture of the common shell becomes a very simple matter. By the welding process, it is quite feasible not only to join iron to high carbon steel, but to weld wrought iron or steel to steel castings or even to cast iron. Hence, in this case, it is only necessary to substitute common iron or low carbon steel tubing and stamped or cast heads and bases and perform the welding operation. The shell which is thus cheaply put together has all the advantages of wrought and none of the disadvantages of cast metal. If made of low steel, it may even be hardened to a certain extent and thus have more or less efficiency against thin armor.

In regard to the shrapnel, a single look at this section will show the problem and how it has been met. This is from a design for the United States army 3.2-inch field piece. The head and base are steel castings, which have been heated and compressed to give them density. The body is drawn steel tubing one-fourth inch thick. The projectile was built as follows: First, the head was welded on to the body. Next the brass tube which carries the flame from the fuse to the powder chamber at the base was crimped in at the upper end. The half formed projectile was then inverted and the bullets placed within and the matrix poured about them. Next the diaphragm which forms the front end of the powder chamber was put into position and the other end of the tube crimped in. The shell is now ready for the final weld, and you will notice that the base piece is provided with a shoulder, which after the weld is made, will press closely upon the diaphragm and support it against the shock of the discharge. After the second weld is made, the shrapnel has an unbroken surface enclosing its deadly bullets, and like the other shell is ready to be fitted with rotating band and fuse.

To summarize: these shells can be produced in the method I have described, so that a wrought steel projectile can now be manufactured at less cost than a cast iron one, which except for target practice is almost worthless; and as for armor-piercing shell or even moulded steel shell, there can be no comparison as to cost of production. This same principle can also be applied to solving a still more difficult problem, and one which has hitherto baffled the skill of the inventor, viz., the welding the solid heads on to the large brass cartridge cases now used with the projectiles of rapid fire guns. A rapid fire gun is one having a non-recoil and pivoted mount. It is aimed and fired from the shoulder like an old-fashioned swivel. They range in size up to as large as the 6-inch gun. The ammunition is fixed just the same as the bullet and cartridge of a shoulder rifle. At present, these brass cases are constructed with great difficulty and at much expense by drawing up from the solid ingot, and no one is prepared to make those of the large sizes in this country. By the Thomson process, which also welds brass and copper, this will be an easy matter and the cost should be less than one quarter that now paid by the government for those they are obliged to import.

In conclusion, I will say that it is a well-known fact among ordnance experts that the breech mechanism and the principle of the construction of the present high powered guns are entirely due to American invention, which was, however, forced out of the country by lack of appreciation and was taken up and developed in Europe. I believe the day has come at last when our military inventors will not have to seek their encouragement entirely abroad and I think that in the very near future our government will be supplied entirely by cheap and effective projectiles of the kind I have shown you to-night.

*Paper read by Lieut. W. M. Wood, U. S. N., before the Society of Arts, Institute of Technology, Boston, Oct. 23, 1890.

Street Railway Absorbed.

The City Electric Street Railway, of Little Rock, Ark., known as the "dummy line," has been purchased by the Capital Street Railway Company, which will operate the two lines under one management. The purchase price was about $50,000 in securities of the Capital Street Railway Company, which thus gains control of the city's street railway system, and of the perpetual freight rates of the "dummy line."

The National Electric Light Association.

At a meeting of the Executive Committee, held at the rooms of the Electric Club, New York City, Nov. 7, the following business was transacted: (1) The date for holding the thirteenth convention was fixed for Feb. 17, 18 and 19, 1891. (2) Eugene F. Phillips, of Providence, was appointed chairman of a Committee on Reception and Arrangements, and he is to appoint the other four members of the committee. (3) Gen. C. H. Barney, of New York, was appointed chairman of a Committee on Electrical Exhibits and Transportation, and he is to appoint the other two members of the committee. (4) The Committee on Papers reported the following as promised, and stated that the prospects of securing two or three more important papers are most excellent. Announcements of these will be made later. The committee has not only secured the promise of these papers, but has gone a step further, and named a person to open the discussion on each paper. This must inevitably tend to bring out the best points of the topic, and to greatly add to the interest in and value of the proceedings. The papers promised are as follows: (*a*) "How Can the National Electric Light Association Best Serve the Central Station Interests?" by C. R. Huntley; discussion by A. M. Young. (*b*) "Distribution of Steam from a Central Station," by F. H. Prentiss; discussion by Geo. H. Babcock. (*c*) "Distribution and Care of Alternating Currents," by T. Carpenter Smith; discussion by G. H. Blaxter. (*d*) "The Ferranti System," by C. B. Haskins; discussion by C. L. Edgar. (5) The resignation of Mr. James English as a member of the executive committee was accepted, and Mr. Edward A. Leslie, manager of the Manhattan Electric Light Company of New York City, was elected to fill the vacancy.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, Nov. 10, 1890.

The Consolidated Electric Storage Company reports he sale of 1,500 cells of Julien storage batteries during the month of October.

A Chenoweth conduit manufactured of concrete by the spiral centering method has been laid in Ashburton and Palisade avenues, Yonkers, N. Y., for telephone wires, and the police and fire departments are laying some of the same conduit at High Bridge, New York City.

The Edison Illuminating Company, of Brooklyn, have been very busy lately in the installation of isolated plants; having closed several contracts recently, calling for over 100 Ward arc lamps for incandescent circuits, made by the Electric Construction and Supply Company, New York, and for several thousand incandescents. This company has a special department in Brooklyn for the wiring and construction of isolated plants.

Lower New York seems to be the scene of considerable electrical confusion in these days. A leak from the subway at No. 65 Nassau street, a few days ago, charged the pavement, within a radius of a few feet, sufficiently to cause some curious antics on the part of passing horses. The shocks, however, were very slight, coming as they did from a comparatively low-tension Edison wire, and nothing more than an extemporized circus was the result.

Important Patent Suit.—Suit has been brought in the United States Circuit Court for the Southern District of New York by the Brush Electric Company and the Consolidated Electric Storage Company, of New York, against the Anglo American Electric Light Manufacturing Company for alleged infringement of certain United States patents known as the Brush storage battery patents, owned by the former companies. A preliminary injunction has been asked for. The Consolidated Electric Storage Company and the Brush Electric Company are now vigorously pressing other suits for alleged infringement, more especially that against the Electrical Accumulator Company, of New York.

Mr. J. W. Marsh, of the Standard Underground Cable Company, Pittsburgh, Pa., was in town quite lately, and was much sought after by the favored few who knew of his being in the city. Mr. G. L. Wiley, manager of the New York office, spoke of the sales of cables and wires being up to their usual standard. Twenty one miles of single conductor is being installed in the conduits now being put down for the Buffalo Street Railway Company, Buffalo, N. Y., by the Field Engineering Company, which is installing the National Conduit Manufacturing Company conduit; and also the Indurated Fibre Pipe Company conduit for this railroad, which has adopted an electrical system, but which one, I am not authorized to mention in this issue, not having reliable information as to what company has received the contract.

Hatzel & Buehler, electrical engineers, at 29 W. Twenty-sixth street, this city, have been awarded the entire electrical contract for the new addition to the New York Hospital fronting on Sixteenth street. There will be double the number of electric lights in the new building that are now placed in the old hospital fronting Fifteenth street. The same firm is increasing the plant of the American Express Company, at 65 Broadway, to the extent of 200 16 c. p. lights. The large paper mills of J. C. Kenyon, Baldwinsville, N. Y., are being equipped with a complete plant of 160 lights, and the company is rewiring the stables of the Second Avenue Railroad Company, this city. Messrs. Hatzel & Buehler have just completed the rewiring of the arc light circuits at the depot of the New York, Lake Erie & Western Railroad Company at Jersey City, N J.

W. T. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 8, Cook Building, cor. Franklin and Congress Sts.
BOSTON, Nov. 8, 1890.

Mr. Walter I. Thurston, of the Providence Electric Supply Company, made us a pleasant call this week.

The Jewell Belting Company, of Hartford, Conn., is fitting the new electric light plant at Bristol, Conn., with its belting, the main belt being a 28-inch double one.

The Standard Electric Company, of Vermont, is installing a 500-light generator at the Worcester Woolen Mills, Worcester, Mass., and a 300-light machine for the Carolina Mills Company, Carolina, R. I.

Clambake Photographs.—Messrs. Heald & Co., of Providence, R. I., have ready for delivery the photographs of the group at the clambake of the American Electrical Works for 1890, and will send them, all packed, for $1.25.

Strike at the Thomson-Houston Works.—The armature winders of the Thomson-Houston Electric Company struck this week to resist a reduction in wages. Fifteen of the sixty men employed in this department on railway motors quit work.

West End Railway.—Since the Egleston square electric line started travel has increased 33 per cent. Although the West End has been running double the number of trips formerly run by the horse cars, it has been unable to accommodate the traveling public.

Mr. W. Brown, general manager of the New England Printing Telegraph Company, is at present laying out a new line from Danielsonville, Conn., to New York. When completed the company will have a line composed of two No. 6 and 12 No. 14 hard drawn copper wires between the two cities.

The Providence Electric Supply Company is wiring the new Jones Building at Providence, R. I., and will install between 300 and 400 lights. This company has just wired the Pilgrim church for 100 lights and is installing a 15-h. p. Thomson-Houston motor for running an elevator at the Boston store.

Boston Electric Club.—The first dinner of the season of the Boston Electric Club will take place at Young's Hotel Monday evening, Nov. 10, at 6.45 P. M. Professor Elihu Thomson will deliver an address on "The Properties of Alternating Currents," and will illustrate the subject with practical experiments.

The Dividend on Thomson-Houston preferred stock, an announcement of which some time ago made it appear that this would be $3.50 per share, will not be due until Jan. 1, and as this is a seven per cent. dividend, payable semi-annually, it will be seen that on the par value of $25 per share the amount will be but 87½ cents instead of $3.50 per share.

Small Motors in Waltham, Mass.—A 5 h. p. motor has been set up in Stark's machine shop. A 2 h. p. motor has been ordered by D. D. Palmer, and smaller motors will be introduced for running sewing machines, ice-cream freezers and work requiring less than 2 h. p., while a number of printers are considering the introduction of electric power in their establishments.

A 250 Horse Power Dynamo.—The great 250 h. p. generator in the testing house of the Thomson-Houston Company at Lynn, Mass., is now furnishing power to run the several lines of the Lynn & Boston Railroad, the Highland circuit, Wyoma and Walnut streets, which were deprived of power by the recent explosion of the fly wheel in the station of the Lynn Gas and Electric Company.

"From the Forest to the Foot" is the title of a new book just issued by the Boston Rubber Shoe Company, manufacturers of the "climax tape." This work is the compilation of Mr. G. L. Richards, and is copiously illustrated, showing the different processes that rubber passes through until it is placed before the trade. It is undoubtedly a valuable publication, and reflects great credit upon the ability of Mr. Richards.

A Recording Electrometer.—The Meteorological Observatory of the Massachusetts Agricultural College has recently received a delicate apparatus for keeping a continuous record of electric potential of the atmosphere. It consists of an automatic electrometer, the ordinary water drop apparatus for picking up the air potential, and a photographic registering apparatus. This consists of a cylinder operated by clock-work and carrying the sensitive paper on which a spot of light is focussed from the mirror of the electrometer. The arrangement enables a perfectly continuous record of the potential variations in the atmosphere to be kept.

The Evans Friction Cone Company reports sales for the equipment of the following plants: Lebanon Electric Light Company, Lebanon, N. H., one 65 h. p. alternator; W. S. Griffiths, Philadelphia, two 200-light Mather machines; Washington Electric Light and Power Company, Washington, Pa., one 50 h. p. alternator; Hopedale Electric Car Company, Hopedale, Mass., two 30 h. p. generators; National Transit Company, Oil City, Pa., one Edison dynamo; Rhodes Manufacturing Company, Philadelphia, two 30-light dynamos; A. M. Church Company, Troy, N. Y., one 20 full arc U. S., one 50 incandescent; Belfast Electric Light Company, Belfast, Me., one 500-light alternator, one 300-light alternator; Edison General Electric Company, one No. 4 Edison dynamo; P. A. Glatfetter, Spring Forge, Pa., one 400-light Mather, one "K," two Thomson-Houston; Towanda Electric Light Company, Towanda, Pa., two 400-light Weston, one 500-light National, all equipped with the Evans friction devices.

The Southern New England Telephone Company has bought a large brick house in Bridgeport, Conn., and is remodeling it, and, when finished, will have a complete building of its own, modeled after the new building at Hartford. At present they have at Bridgeport 386 grounded circuits. It will lay at once 35,848 feet of ducts and 14 underground cables, with a total length of 17,924 feet; entire length of trenching underground will be 5,263 feet, with 16 manholes; the new cables will accommodate 700 metallic circuits—in fact, all the plans will contemplate accommodating just double the amount of service that it can now handle. The telephone offices in the new building will be situated on the second floor, including operating room, manager's office, sitting room for lady operators, and toilet rooms. In the basement will be the heating apparatus, opening to underground tunnel and repair department. To show the remarkable growth of the telephone business, the extra territorial calls of this company for the quarter ending October, between exchanges in Connecticut, were 55,287 messages This company, through its general superintendent, E. B. Baker, is alive to all improvements that will be a benefit to their service; the latest arrangement is the purchase of 13 time stamps of the type made by the Automatic Time Company, of Boston, for stamping tickets; these stamps noting the hour and minute when connection was made, and it is estimated, saving 30 seconds of time for each call. This company will, on Nov. 1, adopt the idea of employing lady operators for all-night service. At present only one exchange in the country does this, Brooklyn, N. Y., but it has been found to be very successful there. The New Haven office will have one lady assistant chief operator and three regular operators for this night service. The company has lately installed 30 long-distance loops in Meriden and 20 at Middletown. At present they have 6,000 telephones, 10 per cent. of which are equipped with long-distance transmitters, which is a remarkably large average.

L. H. H.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
31 CITY BUILDING, PHILADELPHIA, Nov. 8, 1890.

Alexander Bros are to illuminate their belting factory and office with a 75-light plant of the La Roche system.

The La Roche Electric Company is installing a 200-light plant for the Rishel furniture factory at Hughesville, Pa.

A fire at the electric and gas fixture factory of Mark Simons, at Fourth and Laurel streets, last week, resulted in a $2,000 loss.

Alexander Bros. have an order from the Heisler Electric Light Company for one of their double leather dynamo belts.

Mr. G. A. Wilbur has just returned from a two weeks' trip to Fort Wayne much elated over the prospects of the coming business.

High Bros. & Co. are putting a 12 h. p. automatic Payne engine in the works of the Crosscup & West Engraving Company, 907 Filbert street, for running the dynamo.

Mr. O. D. Pierce has just returned from a trip through Pennsylvania with a good number of orders for the Perkins' lamp for which he is the sole agent in this section.

The Crandell Manufacturing Company has removed to more commodious quarters at 12 South Fourth street, and has taken the agency for the Crocker-Wheeler motors.

W. S. Griffith & Co. are installing a 25 h. p. arc light plant, including wiring and the construction of a series of electric signals, for the Knoxville Incline Railway, of Pittsburgh, Pa.

The Quaker City Electric Company is installing a 50-light plant for Snell & Meharg, Hamburg, Pa.; a 30-light plant for Dorner & Vieser, Camden, N. J., and a 10-arc light plant for Wm. Gray & Sons, Lee, Mass.

Favorably Reported.—At the last meeting of the Electrical Committee of Councils an ordinance providing for the laying of conduits for underground wires on Spring Garden street, together with the necessary iron poles for the lights, by the Department of Public Safety was ordered to be favorably reported to Council.

M. R. Muckle, Jr., & Co. are installing for the Martin & William H. Nixon Paper Company, in its city mills, Philadelphia, an electric light plant of 120 16 c. p. lights. The dynamos will be driven by a 10 h. p. Westinghouse engine which the Messrs. Muckle put in for this company about one year ago. The engine was used for a temporary drive, and now that the necessity for it is over it will be utilized in this way.

The two fine plants which Vallee Bros. are installing at the Williamson School and the House of Refuge are being pushed to completion, and are under the personal supervision of Messrs. John Hoskins and Carl Hering, the well-known electrical engineers. All the wires running from the dynamo rooms to the different buildings are to be put underground, and the work is laid out in such a manner that there cannot be more than 2 per cent. loss in any one building.

Messrs. Hooper & Townsend, of Thirteenth and Buttonwood streets, have decided to light their entire works by electricity, and for this purpose have placed an order with Messrs. M. R. Muckle, Jr., & Co. for 600 lights of 16 c. p. The plant will consist of two Westinghouse engines and two 300-light compound wound dynamos. The engines and dynamos will be so arranged that each engine can drive either or both dynamos, reducing the chances of a breakdown to a minimum.

The Otto Gas Engine Company, of this city, has just shipped one of its 50 h. p. engines to the Hamilton Gas Light and Coke Company, of Hamilton, O., which has put in a new incandescent plant, and one 50 h. p. for the Aurora Gas Light Company, also to operate a Fort Wayne incandescent plant. The company is working on orders for a 50 h. p. engine for the Centerville Gas and Electric Light Company, of Centerville, Ia., and a 30 h. p. engine for the Charleston Gas Company, of Charleston, W. Va., which will operate a Fort Wayne incandescent plant.

Another Electric Road.—A charter has just been granted for the Chenango Valley Street Railway to operate an electric line between Sharon and Sharpesville, Pa. The route has already been located and the management will at once make application to the proper authorities of Sharon and Sharpesville for the necessary privileges, and to secure the right of way along the proposed route. From the feeling of the citizens they will meet with co-operation from everybody along the line, as its construction will be of the greatest convenience to the public. As soon as some further preliminaries are completed, the books of the company will be opened for subscriptions to stock, and it is believed that a few months will see the enterprise under good headway.

The Summer Hill Mines at Woodville, Pa., have just been equipped with a complete electric plant of mining machinery. The power plant consists of one Westinghouse junior engine, one 30 horse power three-wire, four-pole Westinghouse alternate current generator, six Hercules coal mining machines, a 12 foot fan with a capacity of 30,000 cubic feet per minute, centrifugal pump, etc. The mining machines and the pump are operated by three horse power Tesla motors. The entire equipment has been furnished by the Westinghouse Electric and Manufacturing Company. A careful record of the work of the mining machines in the Willock mine, which is also operated by Westinghouse electric mining appliances, shows that from July 1 until Aug. 3 each cut represented about 1 1-10 tons of coal. It was found that it was impossible to keep the rooms cleaned up of the coal that was brought down fast enough to give the machines a chance to test their full capacity. Each machine is doing the work of from 12 to 14 pick miners.

Business Change.—Mr. W. A. Stadelman, who has for some time been connected with the firm of Chadbourne, Hazelton & Co., of Philadelphia, has recently severed his active interest in that concern, and has reorganized the Equitable Electric Railway Construction Company, of which company he was chief engineer, and will devote his entire energies to the new concern. The new company will be known as the Equitable Engineering and Construction Company, and a new charter has been applied for which will give the company the right to not only equip electric railways but to buy and sell or lease or operate them. The old company will go out of business by liquidation, and the new company will take its place. Handsome new offices in the Drexel Building have been taken, and the company has already several large contracts, one for an electric railway in the South, and one for a complete central station, alternating current lighting plant, including engines, boilers, buildings, etc., to be erected near Philadelphia. The capital of the new company is $50,000, and the officers are as follows: J. A. McKee (of the Tradesmen's National Bank), president; H. J. M. Cardeza (of Cardeza, Gilliams & Co.), secretary and treasurer; W. A. Stadelman, manager and chief engineer. The directors are: J. A. McKee, J. L. Stadelman, L. Gilliams, F. D. LaLanne, W. A. Stadelman.

Overhead Wires.—An interesting session was recently held in Philadelphia by a special sub-committee on railroads from the Common Council. The representatives of various railroad companies and electric companies were on hand, along with delegates representing citizens, to discuss the question of overhead electric railway wires. The bills for consideration were the proposed overhead wire systems on Germantown and Jersey avenues, Lehigh avenue, and Twenty-second street and Allegheny avenue, and over the route of the Holmesburg, Tacoma & Frankfort Electric Railway Company. Mr. Mansfield, of the Thomson-Houston overhead company, spoke emphatically in favor of the experience with overhead wires in Boston, and urged the adoption of the bills in question. He further said that the storage battery and the underground conduit had proved themselves inefficient, and if you have electricity at all, it must practically be through the overhead system. His position was strongly re-enforced by Mr. Wharton, Jr., president of the Lehigh Avenue Railway, who said that he had been working for five years to get a good storage battery car. In the end he had evolved one which was thoroughly satisfactory mechanically and electrically; but that

it was not a success financially. He was thoroughly convinced that the overhead system was safe, and should be adopted. Mr. Wharton's candid statement of the difficulty of making storage battery cars pay, even when the apparatus was of the best, was not concurred in by several advocates of storage battery systems who were present. Altogether, the amount of evidence brought in was large, and it was of a most interesting character, generally tending to show that the overhead wire, while it might not be all that could be wished, was decidedly preferable to lacking electric power entirely; and the other systems of supplying electricity had not been successful. W. F. H.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
465 THE ROOKERY, CHICAGO, Nov. 8, 1890.

The City Water and Light Company, of Abilene, Kan., has been incorporated at Chicago; capital stock, $250,000; incorporators, C. F. Coffin, B. A. May, and I. D. Martindale.

Paw Paw, Mich.—A franchise has been granted to Harrison Brothers for the erection and maintenance of an electric light plant, but the apparatus and supplies have not yet been purchased.

The American Conduit and Traction Company has been incorporated at Chicago to make and sell electrical conduits, etc.; capital stock, $1,000,000; incorporators, H. B. Hallock, H. M. Day, and C. P. Chapman.

Madison, Wis.—The Madison Water Works, Lighting and Power Company has been incorporated with a capital stock of $20,000, to supply water, light and power; incorporators, C. C. Rainwater, Charles D. McClure, and Moses Ramsey.

To Manufacture Incandescent Light Joints.—The Adjustable Incandescent Light Joint Manufacturing Company has been incorporated at Chicago, with a capital stock of $50,000; incorporators, John Long, Cornelius Gaffney, M. F. Clark.

Mr. C. J. Thompson, of St. Paul, Minn., as agent for the Continental Dynamo Company, New York, is installing two plants in the city of St. Paul, one for 250 lights in the St. Paul High School, and a 30 light dynamo in the works of the St. Paul Linseed Oil Company.

Mr. Thomas Palmer Whittier, of Saginaw, Mich., has been visiting friends in Chicago during the past ten days. Mr. Whittier is interested in several electrical companies, and also has several devices of his own that will shortly be placed on the electrical market.

Mr. Channing T. Gage, Michigan agent of the Heisler electric light system, has sold a complete Heisler electric light plant, with a capacity of 200 lamps of 32 c. p. each, to the Craig Wheat Cleaner Company, of Oxford, Mich., for general commercial use and for street lighting.

Friction Clutches.—The manufacture of friction clutch pulleys and other power transmitting machinery, formerly conducted as one branch of the business of the Eclipse Wind Engine Company, of Beloit, Wis., has been transferred to the Eclipse Clutch Works, now a separate concern.

The Boughen Engineering Company, of Cincinnati, is issuing a handsome catalogue of interest to all users of steam or prospective purchasers of steam plants, as within its 100 pages are illustrated and described all the various apparatus and accessories that go to make up a complete steam installation.

The Central Electric Company is to be congratulated upon the acquisition of Mr. George W. Vernor, who takes charge of the bookkeeping department. Mr. Vernor has been Secretary of the Southern Electrical Supply Company, at St. Louis, for the past year, and is already well known to the electrical trade.

Mr. Herbert Wadsworth, western manager of the Excelsior Electric Company, Chicago, has sold three 50-light arc dynamos of the new type of Excelsior make, complete, in Findlay, O., in Macon, Mo., and in Marseilles, Ill. Mr. Wadsworth also disposed of three arc light Excelsior dynamos to Chicago firms during the week.

Mr. Frederick Sargent, the well-known electrical engineer of Chicago, has just returned from Ogden, Utah, where he has charge of the planning and construction of the extensive electrical plant that will be located at the mouth of the cañon, deriving from the heavy fall of water the necessary power to generate the current required in operating electric lights, street railways and motors.

The Thriving Electric Manufacturing Company has taken up its quarters in the Davis & Rankin Building, corner Peoria and Fulton streets, Chicago. This company has just closed a contract with the Pond Engineering Company for a 100-h. p. Armington-Sims engine, and with the Westinghouse Electric and Manufacturing Co. for a 500-light alternating current dynamo and exciter.

Mr. John R. Markle, of Detroit, has been a welcome visitor in Chicago this week. Individually, and as president of the Markle Engineering Company, of Detroit, Mr. Markle has been one of the pioneers in the development of the established methods now adopted and approved throughout the field of electrical engineering, and this long experience in construction work and the practical requirements of everyday installations gives some slight indication of the value of his services in the selection of machinery, and in the construction of both steam and electrical plants.

Recent Sales.—The isolated lighting department of the Thomson-Houston Electric Company's Chicago office reports the following sales of isolated plants: Sonneidewend & Lee Company, Chicago, 300 incandescent electric lights; Johnson Locke Mercantile Company, San Francisco, Cal., for the California Pumice Company, at Napa, Cal., 50 incandescent lights; Fecker Brewing Company, Chicago, 50 incandescent lights; Chicago Anderson Common Brick Company, town of Lyons, near Chicago, 48 arc lights; and the McCormick Harvester Machine Company has placed an order with this department for a 16 arc light, second-hand outfit, for the blacksmith shop.

Telephone Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone stocks as follows:

Chicago	$298@$300	Cumberland	$ 59@ $60
Central Union	60@ 62	Wisconsin	117@ 118
Michigan	94@ 96	Bell of Missouri	155@ 160
Great Southern	32@ 35	Iowa Union	20@ 21
Colorado	38@ 40	Missouri and Kansas	55@ 57
Rocky Mountain Bell	40@ 45		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$93@$ 96	Chicago Edison Co	$130@$132

The Shaw Electric Crane Company, of Milwaukee, Wis., is now building for the Alex. Rarig Company, Columbus, O., two 15-ton electric traveling cranes, having a 48-inch span; for the E. P. Allis Company, Milwaukee, Wis., one 30-ton E. T. Crane, 50-inch span, their third order, they now having in use one 25-ton and one 15-ton crane; for Samuel L. Moore & Sons Company, Elizabethport, N. J., one 20-ton E. T. Crane, 52-inch span; for Pratt & Letchworth, Buffalo, N. Y., one 10-ton E. T. Crane, 56-inch span. They have just shipped one 15-ton E. T. Crane, 29-inch span, to Robert Whitehill, Newburgh, N. Y., and started two weeks ago a 15-ton crane for the Pond Machine Tool Company, Plainfield, N. J.

ST. LOUIS, MO., Nov. 7, 1890.

Mr. M. M. Hayden, of the Law Telephone Company, New York, is in the city, en route home from San Francisco after a very successful trip.

Mr. H. B. Morgan, of the Chas. Munson Belting Company, Chicago, was a welcome visitor in St. Louis this week, and during his stay secured orders for several large size leather belts.

Mr. W. B. Phillip, manager of the St. Louis office of the North American Construction Company, is having excellent success in completing the work on hand and in securing new contracts.

Mr. J. A. Vail, the St. Louis manager of the Hooven, Owens & Rentschler Company, has established a remarkable record for the number of Hamilton-Corliss engines he has placed in operation in the immediate vicinity.

Mr. Walter F. Smith, the general manager of the Heisler Electric Light Company, returned to Philadelphia last week. Mr. Smith will shortly have a handsome catalogue in press and the business of the company will be pushed more energetically than ever.

The Columbia Incandescent Lamp Company, of St. Louis, has recently added new pumps and other apparatus that enables it to turn out a greater number of incandescent lamps than heretofore. It has also appointed two or three live agents who will see that prospective customers are fully posted on the merits of the Columbia lamp.

The Union Electrical Construction Company, 312 North Eleventh street, St. Louis, has secured the local agency of the Card Electric Motor and Dynamo Company of Cincinnati. The company also represent the Western Electric Company of Chicago. Among last week's sales was a 150-light Western Electric incandescent dynamo which was installed in Stecher's big cooper shop.

The St. Louis Electrical Supply Company, 403 North Eighth street, has completed the additions and changes in its store room, and is now better equipped than ever to look after the interests of its customers. It is making a specialty of electric railway supplies of standard design, and is also carrying a well-assorted stock of electrical books of interest to the expert, as well as the beginner.

CINCINNATI, O., Nov. 7, 1890.

The Probate Court has overruled the motion to compel the Edison Company to provide a plant before opening up any more streets.

Cincinnati Electric Light Company stock sold on the Stock Exchange on Saturday at 1.40, closing at 1.37½ bid and 1.40 asked regular, and 1.38 bid for 175 shares. Davis Anderson had unloaded 800 shares on Thursday at 1.60.

Henry Hanna, one of the leading capitalists of Cincinnati, will hereafter officiate as the head of the Bell Telephone Company, of this city, in place of the late A. D. Bullock, the latter having been president of the company. This arrangement will continue, it is understood, until the regular election, at the annual meeting.

The Edison General Electric Company has secured a site for a plant, though there may still be a hitch in the negotiations, as one of the lots has been said to have a doubtful title. The plans went to New York for ratification by the home office last week, but the matter leaked out and was published here. The Board of Public Improvements insisted that the company should show a deed to a site before it would be allowed to lay any more conduits, and Gov. Foraker assured the Board the deed would be signed at once. The property secured is 100 × 98 feet, and was bought of several holders. It is located on the north side of Eighth street, between Elm and Plum streets. It is within 200 feet of the new city hall now building, and four squares from the plant of the Brush Electric Light Company.

LOUISVILLE, KY., Nov. 7, 1890.

The Gaynor Electric Company has just booked an order for 80 incandescent lights for the Tarascon Woolen Mills.

The New Albany (Ind.) Electric Light Company is fast doubling its capacity and proposes to furnish electricity almost as cheap as gas.

The Thomson-Houston branch office here is being enlarged, and when present work is completed it will have one of the finest fronts in that line on Main street.

The Gooch Electric Light Company has been incorporated by a number of Louisville capitalists. It succeeds to all the franchises of the Gooch Electric Company.

Lighting a Railroad Depot.—The contract for lighting the big new Louisville & Nashville station at Tenth street and Broadway was advertised to be lit Saturday. Twenty arc and 1,000 incandescent lamps will be required. The awards will not now be made for three weeks.

The Edison General Electric Company has just taken an order, through its representatives here, to put in 10 arc and 360 incandescent lamps for Frank Fehr's new brewery building. It has also a contract to put in 500 incandescents for the Central Station plat at Bowling Green, Ky.

A new company has been incorporated at Covington, Ky., known as the Covington, Cincinnati and Rosedale Electric Railway Company. It will run electric cars out from Cincinnati through Covington and then south a mile and a half to a prosperous suburb. Suburban real-estate owners are pushing the scheme.

The Union Railway Station being built by the C. P. Huntington line at Seventh street is nearly ready, and will be lighted with 20 arc and 183 incandescent lamps. Bids have not yet been advertised for. The new building of the Louisville Trust Company, which will be equipped with 630 incandescent lights, is also nearly ready.

Advertised for Bids.—The mayor of this city has advertised for bids to furnish the city with 150 arc lamps for street lighting purposes, to be distributed as directed. The proposals are for 2,000 candle power lights, and must include attendance, cleaning, etc., and $50,000 indemnity bond is required for faithful performance of contract and to save the city the costs of any suit for infringement, etc.

Lexington, Ky.—The spirit of opposition to the electric street railroad in Lexington is fast passing away. The company is rendering excellent service, and is so conservative in all its methods that a general feeling of distrust has given way to a feeling of confidence, now that the residents of that city have had a chance to test the merits of the new means of transit. That seems to have been the result all over the South, wherever the electric cars for treet railways have been tried.

Directors Replace the Strikers.—There was a small strike of the Lexington motor men a short time ago. The company remained firm, and the officers and directors, prominent citizens, operated the cars themselves till the strikers could be replaced. The work of the gentlemen and their method of dealing with strikes were applauded, and the scene was altogether at variance with the traditional "stuck up" ideas of the average Kentucky colonel and his abhorrence of that sort of work.

Street Railway Work.—The Fourth avenue street car line, which has been delayed so long on account of a congestion of orders at the motor factory, is now receiving the finishing touches. The poles and span wires for stringing the trolley lines have been up for months, and now the street is torn up for the purpose of laying the ground wires along the tracks. It was expected to have the cars running more than a month ago, but the delay in the shipment of the motors prevented. It is now hoped to have the cars running in a couple of weeks. It was hoped to have the Market, Shelby, Walnut, Eighteenth and Chestnut street lines in operation by electricity instead of mule power by this time, but the same delay has prevented and there seems now no telling when the change will be made. The new motors are needed badly, as those in use have proved so successful that people in all parts of the city are making demands for them instead of the mule cars, on account of the rapid transit. F. DE L.

SOUTHERN NOTES.

NORFOLK, Va., Nov. 8, 1890.

Raleigh, N. C.—An isolated electric light plant has been installed in the new cotton factory.

Ashville, Ala.—J. A. Hodges and others have organized a company to establish an electric light plant.

Belton, Tex.—An additional dynamo is being added to the plant of the Belton Electric Light Company.

Orange, Tex.—The Orange Foundry and Machine Shops have recently installed an isolated electric light plant.

Houston, Tex.—An electric railroad will be built by a company which S. Taliaferro and others are now organizing.

Charleston, W. Va.—An electric light plant will be established by the South Charleston Improvement Company.

Galveston, Tex.—A company with a capital stock of $25,000 has been organized to manufacture phonograph appliances.

Athens, Tenn.—The Athens Electric Light and Power Company has been organized and will erect an electric light plant.

Max Meadows, Va.—An electric light plant is to be established by the Max Meadows Land and Improvement Company.

Kingwood, W. Va.—An electric light plant will be established, and the Edison Electric Light Company have the contract.

Cedartown, Ga.—J. H. Allen and others have obtained a franchise from the city council to construct an electric street railway.

Arkadelphia, Ark.—An electric light plant will be established, and bids are now invited. G. W. Carder can give particulars.

Eagle Rock, Va.—A company, of which T. B. Jackson, of Cincinnati, is president, and G. K. Anderson secretary, will erect an electric light plant.

Tallapoosa, Ga.—An electric light plant has recently been put into the foundry and machine shops of the Tallapoosa Foundry and Machinery Company.

West Point, Ga.—The Planters' Oil and Manufacturing Company has increased its capital stock to $75,000, in order to establish an electric light plant.

Jackson, Miss.—The Jackson Land and Improvement Company are getting estimates on the cost of constructing an electric road three miles in length.

Troy, Ala.—The city council is discussing the advisability of establishing an electric light plant, and desires estimates for both arc and incandescent systems.

New Castle, Va.—J. M. B. Cripps will establish an incandescent electric light plant. He is now in the market for the necessary machinery, and desires estimates.

Temple, Tex.—The Temple Electric Light Company has been incorporated by T. Smithers, Nelson K. Smith and F. F. Downs. They desire estimates on the necessary equipment.

Bartow, Fla.—J. W. Brady, J. O. Clount, and others, in conjunction with the Thomson-Houston Electric Company, of Boston, Mass., will probably establish an electric light plant.

Terrell, Tex.—The new electric light plant is finished and lights have been turned on. The company owning this plant is composed of John L. Terrell, T. F. Boroler and J. M. Powers.

Asheville, N. C.—An electric line is projected to connect with the present Asheville system, and the proposed electric line to Biltmore, the palatial home of George Vanderbilt, near Asheville.

Griffin, Ga.—An electric light plant will be established by the Griffin Water Company, recently incorporated with a capital stock of $75,000, by W. A. Robinson, J. T. Robinson, and E. R. Hulbert.

The Westinghouse plant in Waycross, Ga., has been receiving some large accessions to its lighting service, and there is every prospect of running the station to its full capacity during the winter.

Chattanooga, Tenn.—The Lookout Mountain Incline Railroad Company, which is preparing to build an incline railway up Lookout Mountain, will also build an electric line to connect with the incline road.

Chester, S. C.—The city council has contracted with the National Electric Company for the establishment of an electric light plant, to be in operation by April 15. There are to be 80 incandescent lights.

Laredo, Tex.—The Electric Street Railway Company contemplate the early establishment of an electric light system in connection with the operation of their line, which will make two light plants for the city.

Texarkana, Ark.—The Texarkana Gas and Electric Railway Company, recently reported incorporated, has organized with a capital stock of $500,000. J. Deutschman is president, and F. P. Openhauser is secretary.

Blackhorse, W. Va.—McMahon, Porter & Co., who operate one of the largest sewer pipe works in the country, have contracted for the erection of an electric light plant, capable of furnishing 100 incandescent lights and a number of arc lights.

Birmingham, Ala.—The Birmingham Railway and Electric Company has issued $1,500,000 in bonds, with the Central Trust Company of New York as trustee, for the purpose of obtaining funds for changing its motive power to electricity.

New Braunfels, Tex.—An electric light company is constructing an electric light plant on the banks of the Comal River, which has a fall of 45 feet, within a flow of four miles. The plant

is already in possession of 4,000 h. p., derived from this river, and the company is putting in machinery for the transmission, by electricity, of 100 h. p. to a large cotton gin some distance off.

Austin, Tex.—A movement is on foot to establish an electric railway, to run into the suburbs, the electricity to be generated by water power. It is stated that the present street railway company is thinking of changing to electricity, generated in the same way.

A Popular Official.—Mr. J. A. Baldwin, late traffic chief in the Western Union Telegraph office, in Atlanta, Ga., has recently been appointed train master for the Atlantic & Florida Railroad, and has accepted the position. Mr. Baldwin was highly esteemed by every one connected with the Western Union office, and upon his departure was presented with a handsome gold watch, chain and seal, by the gentlemen with whom he has been associated so long. Mr. E. C. Dunn has succeeded him as traffic chief.

Salem, Va.—The City Council has invited proposals for not less than 30 arc electric lights. The proposals are to state the cost of arc and incandescent lights for streets and avenues, and incandescent lights for City Hall, council rooms and other buildings owned and controlled by the city. The charges are to be in accordance with the number of lights used, and the charges are to be graded, in the same way, for business and other houses—the candle power to be stated in each case. The contracting party will have a right to put up poles, wires, etc., and the contract is to be for five years, after which the city is to have a right to purchase, the price to be fixed by arbitrators.

Fire in a Telephone Office.—Last Sunday evening, in Richmond, Va., an electric light wire crossed a telephone wire at some point in the city, this set fire to the switchboard and paraffine wires in the central telephone office. The operator telephoned Supt. Thompson that he was being "burnt up." Mr. Thompson at once sent in his signal, "10—10," which requires the electric plant to shut off its current, and he then ran down to the central office and helped the operator to extinguish the fire, without turning on an alarm. The loss to the telephone company was quite heavy, one of their 50-wire cables being burned out, which interfered also very seriously with the service in various parts of the city.

Richmond, Va.—At a recent meeting of the electric light committee of the city council the resolution passed by both branches of the council empowering the committee to advertise for bids to furnish the city with electric lights for the period of twelve months, or for shorter time if practicable, from the 8th of February, 1891, came up for consideration. It was intimated that the Schuyler Company would not bid for a shorter period than five years. One member of the committee thought this would be a good thing, as it might compel the city to have its own plant. Mr. Traylor, of the Traylor Electric Company, was present and said his company would bid for a year. One member favored the discontinuance of the use of incandescent lamps altogether, and another favored a six months' contract. Finally it was decided to advertise for bids to furnish 134 electric lights (the present number), for one year from Feb. 8, 1891, and Nov. 15 was designated as the time for opening the bids.

Atlanta, Ga.—"Headquarters, Fourth District, W. U. T., Charles G. Merriwether, Superintendent," is the inscription on the door leading to spacious offices of the Western Union Telegraph Company. Mr. Merriwether and the members of his family arrived in Atlanta recently to make that city their home. Mobile has been the headquarters, and Mr. Merriwether the superintendent of the telegraph company's operating lines in the South since Nov. 1, 1864. On that date he was sent by the Southern Telegraph Company and the Confederate Government to assume the duties he has since so acceptibly performed. His remembrances of his official connection with the Southern Telegraph Company, with the Confederate Government with the United States Government, with the American Telegraph Company, and with the Western Union Company, are most interesting, and show that faithful and intelligent performance of duties is carefully noted and appreciated.

Richmond, Va.—The council committee on electric lights recently ordered thirty-four of the electric lights to be taken down on account of the lack of funds. Mr. George E. Fisher, general manager of the electric company, says he cannot account for this action, as his company had offered to let the city continue using these lights, and pay for them at her own convenience, in either three, six or twelve months time. The action of the committee in this matter has created a good deal of unfavorable comment, and one of the city papers, in alluding to the matter, says: "Intelligent opinion will not sustain the council. Every public-spirited citizen of Richmond is ambitious to have the city advertised as it merits. So far from decreasing the number of arc lamps on the streets, there is a hope that before long the present number will be doubled. The people are no more willing to return from electricity to gas than from gas to oil or tallow-dips. This is a thriving city, and if we persistently decline to make known that fact to the wide world, the least we can do is to refrain from proclaiming a poverty that does not exist. The money for the full quota of electric lamps should be furnished at once. If it is not in the treasury it can be gotten. There is no doubt about this. Richmond is rich and prosperous; her debt is moderate considering her assets; her credit is good and the tax-paying people will not consent to be told that the small amount of money asked by the committee cannot be obtained. Away with all such unbusiness-like and depreciatory ideas." Mr. Fisher says that at the expiration of the present contract for the electric lights, in Febuary next, his company would offer bids, which he thought would compete favorably with any other company desiring the contract. Y. N. B.

ENGLISH NOTES.

(*From our own Correspondent.*)

LONDON, Oct. 22, 1890.

Willan's Engines and Edison-Hopkinson Dynamos.—Owing to the restricted space of the majority of central stations in this country and to the fact that the machinery is required to be as nearly noiseless as possible, Messrs. Willan & Robinson's triple expansion high speed engines coupled direct to the dynamos have had considerable vogue. An instance of the remarkably high efficiency which can be obtained by this combination is shown by some recently published tests. The engine took steam at 120 pounds pressure and ran at 430 revolutions, and it was coupled direct to an Edison-Hopkinson dynamo, giving 110 volts and 475 ampères. The ratio of the useful E. H. P. given out by the dynamo to the E. H. P. of the engine was 86.7 per cent., the electrical efficiency of the dynamo being 96 per cent. This particular combination was intended for an installation in the city of Messrs. Spiers and Pond, the well-known restaurateurs.

The Deptford Central Station.—I hear on good authority that the Directors of the London Electric Supply Corporation are actively buying up any shares of this company that may be in the market. The shares have lately been quoted as low as £2, but they have now risen to £2⅜ and £2⅝. I understand that this purchase of shares on the part of the directors is not a financial move, but arises from the conviction on their part that Mr. Ferranti has at last overcome the many difficulties with which he has been contending for the past two years. I also hear on good authority, that the machinery at Deptford is working in a highly satisfactory manner. The dynamos are at present generating a large amount of current, which is sent into London, along the new Ferranti mains. Both of the 1,500 h. p. engines and dynamos are working admirably and have now been supplying current continuously to 40,000 lamps for more than a fortnight. As an example of the exaggerated rumors, which crop up in connection with this station, I may mention that a report has been going about that an employé was recently killed at Deptford while engaged in disconnecting a wire. According to the company, the only foundation for this report was that an accident happened to one of the workmen, who had his arm drawn among the machinery and crushed. The post office officials state that although they can always tell at the central telegraph office when the Deptford dynamos are running, yet their instruments are no longer seriously interfered with.

Explosion on a Yacht.—An explosion took place a few days ago on board the steam yacht "Pathfinder," belonging to Earl Poulett. The vessel is lighted throughout by electricity, and the accumulators, which had been previously stowed away in the coal bunkers, had recently been placed on deck and carefully covered in. During a violent storm of rain the steward reported a leak in his cabin from the deck. On going to examine the cause, Lord Poulett discovered that the water came down through an opening in the deck, through which passed one of the leads from the dynamo to the accumulators. It being dark, a match was struck, and, according to the daily press accounts, "immediately a terrific explosion took place, the yacht being shaken from stem to stern and, on going on deck, Lord Poulett saw that the whole of the accumulators had exploded and blown the teak cases to pieces, sending the glass fragments and splinters into the air." The daily papers go on to state that the electricians declare this explosion to be one of the most extraordinary things they have ever known and that they can in no way account for it, "as it has hitherto been thought *that under no circumstances can gas be generated in accumulators.*" As a matter of fact, however, the explanation of this explosion is somewhat difficult. The accumulators were on deck, as I have stated before, and the case in which they were placed had a few minutes previous to the accident been opened, and was in addition well ventilated. The existence therefore of an explosive mixture of oxygen and hydrogen gas at the moment the match was struck seems to be out of the question, and it seems to be within the bounds of possibility that the much maligned accumulators had nothing whatever to do with the disaster at all. For although it is stated that they exploded, it is possible that they merely suffered from the concussion of the explosion. This episode, however, has served its purpose and is every where being quoted as "a new danger."

LONDON, Oct. 29, 1890.

The City & South London Railway.—The City & South London Railway will be opened on the 4th of November next by the Prince of Wales. The railway, as I have stated before, runs in two tunnels constructed on Mr. Greathead's system, the principle being exactly the same as the tunnel which is being bored by him under the Hudson River. These two tunnels run side by side for the greater part of the length, but in some parts, owing to want of space and to avoid purchasing property and running under buildings, they are placed one over the other. The gauge of the lines is the ordinary standard, 4 feet 8½ inches. The rolling stock consists of trains of carriages drawn by electric locomotives. The carriages are arranged with seats facing each other, like those of an omnibus, with doors at the ends, and a covered platform connects the three or four carriages of which each train is composed. The locomotives are very interesting. They are about 10 feet long and have one pair of driving wheels, the armature being directly mounted on the shaft. Experiments have been made with geared locomotives, but it was found that no advantage was obtained; on the contrary, the greater weight of the large motors is an advantage. A resistance switch and ammeter is provided in the cab, and on each side is a wrought iron cylinder running the whole length of the locomotive and of a diameter of 12 inches, forming a reservoir of compressed air at 80 to 100 pounds pressure per square inch, which works a Westinghouse brake. The capacity for air storage is sufficient for three times the number of stops that are likely to be made on one trip. The conductor is a 1¼ inch steel bar, square in section, running on the sleepers and laid on glass insulators, the electric pressure used being 500 volts. The cars are lighted by three sets of glow lamps arranged in series. The electricity is generated at the west terminus of the line, where large buildings are erected for the machinery and the rolling stock. Three fine Fowler engines, of 400 h. p. each, drive three large Edison-Hopkinson dynamos directly by link belting; the space being somewhat small, jockey pulleys are used. The engines are of a massive character and the dynamos are exceptionally strongly built in order to stand the sudden variations in the current which will be caused in the working of such powerful motors, which are capable of generating about 100 h. p. An interesting feature of the railway, though not strictly electrical, is the enormous double elevators at each station. These are of a semi-cylindrical shape and are fitted in a huge well constructed on the Greathead system. The elevators are worked by hydraulic pressure of 1,200 pounds per square inch, two large hydraulic mains running the whole length of the rail, the water being returned to be used again. A steep gradient of 1 in 31 connects the terminus of the line with the generating station, and hauling engines are provided for raising and lowering the rolling stock. There are nearly a dozen steam engines altogether, and these are supplied by six locomotive boilers with mechanical stokers. It is proposed at present to dispense with the usual system of tickets, booking offices and ticket collectors, and at first, at all events, the passengers will simply pay on passing through the turnstile at each station.

News of the Week.

THE TELEGRAPH.

A New Telegraph Line.—Sol Palmer, superintendent of construction of the Second Division of the Western Union telegraph system, is in Waco, Tex., with a corps to commence building a new line from Waco along the San Antonio & Aransas Pass Railroad to Aransas Bay, a distance of 200 miles. The material is being distributed.

On a Delayed Telegram.—The suit of Charles Green vs. the Western Union Telegraph Company, brought in the District Court of Harris County, at Galveston, Tex., to recover damages, was entered upon the docket of the United States Circuit Court, Nov 1. He sues to recover the sum of $10,000 for failure to deliver telegrams notifying him of the death of his father.

The American District Telegraph and Messenger Company has been organized at San Francisco, Cal., to establish direct telegraph companies in that state and elsewhere, and to establish facilities for transporting passengers, freight and parcels. The capital stock is $100,000, and the incorporators are: H. G. Platt, W. D. Mansfield, I. W. Thorne, William L. Greenbaum and J. E. Flemming.

Sues the Western Union.—The case of Mary Grimes against the Western Union Telegraph Company for damages, entered upon the docket of the District Court, at Galveston, Tex., was transferred Nov. 1, and entered upon the docket of the United States Circuit Court at that place. The suit is brought to recover damages to the amount of $10,000 and costs of suit for the non-delivery of a message informing the complainant of the death of her husband.

Great Western Stockholders Beaten.—A Chicago paper says that Bates and others, stockholders of the Great Western Telegraph Company, some time ago filed their bill in the Circuit Court to set aside the assessment obtained by the receiver for the payment of the debts of the company, charging fraud and misrepresentation in getting it, and also on the ground that they were not liable beyond $10 on each share, which they alleged they had paid; and for the further reason that they purchased their stock from one Reeve through subscription contracts made with the company, acting as agent of Reeve after Reeve had paid in full for the stock. Judge Tuley dismissed the bill because the complainants had an adequate remedy at law. The Appellate Court affirmed the judgment on the ground that a few stockholders cannot file an independent bill to set aside an interlocutory order of assessment made in another case, even though fraud and irregularity are alleged to have combined to procure the assessment. The Supreme Court of Illinois by its finding just filed at Ottawa recognizes the full force of the grounds of the decisions of the lower courts.

THE TELEPHONE.

The expiration of telephone patents in England will begin Dec. 9, next.

Long Distance Line in Europe.—Telephonic communication is about to be established between Madrid and the Royal Palace of La Granja, a distance of 100 miles.

The Telephone on the Congo.—An electrical company of Antwerp has dispatched by the last steamer which sailed for the Congo all the material necessary for the installation of the first telephone line which is to be placed along the Congo railway. The wires are of phosphor bronze.

Discontinuance of the "News Letter."—The executive committee of the National Telephone Exchange Association has decided that it is undesirable to continue the publication of the *News Letter*, and the issue which was published on Oct. 31 will be the last that will appear. This issue is No. 106 of the *News Letter*.

Scarce Copies.—Any person having spare copies of the *Proceedings* of the National Telephone Exchange Association at its Cincinnati and Providence meetings will find a place for them by addressing the secretary, who will be glad to exchange for copies of the *Proceedings* of any other meeting, or to pay cash for the extra copies.

California Extensions.—The Sunset Telephone and Telegraph Company has applied to the Fresno (Cal.) trustees for a franchise for a telephone line. The company will run a No. 1 copper wire from Fresno to Merced, and put in long-distance telephones. This will connect Fresno with San Francisco, Sacramento and other points. The line will also be extended, although not at once, to Southern California.

Dividend and Quarterly Report.—The Erie Telephone Company has declared a quarterly dividend of one per cent. for payment Nov. 17, to stock of record Nov. 8. The report of the company for the quarter ended Sept. 30 and six months of the fiscal year makes the following comparison with last year:

Quarter, Sept. 30.	1890.	1889.	Increase.
Earnings	$195.903	$178,526	$17,377
†Expenses	140,082	119,911	20,171
Net	$55,821	$58,615	*$2,794
Dividends	48,000	48,000	.....
Surplus	$7,821	$10,615	*$2,794
Since April 1.			
Earnings	$385,296	$355,614	$29,682
†Expenses	271,632	238,583	33,049
Net	$113,664	$117,031	†$3,367
Dividends	96,000	96,000	.....
Surplus	$17,664	$21,031	*$3,367

*Decrease. †Includes construction and dividend on the Bell Company's stock.

SUBSCRIBERS ADDED.			
Quarter ended Sept. 30	276	138	138
Total connected Oct. 1	12,938	11,702	1,236

The Erie Company presents the following statement of the operations of the Cleveland Telephone Company, the Northwestern Telephone Exchange Company, and the Southwestern Telegraph and Telephone Company, for the three months ending Sept. 30, 1890:

Gross income	$195.903 41
Gross expenses (including dividends, payable to proprietary companies of record Nov. 8)	188,082 00
Surplus	$7,821 41
Proportion of dividends received by the Erie Telegraph and Telephone Company	52,290 27
Dividend No. 28	48,000 00
Surplus	$4,290 27
Number of subscribers connected June 30, 1890	14,662
Added during the quarter	276
Total number connected Sept. 30, 1890	12,938

Gross earnings for the same period last year were $178,526; and in 1888, $168,361.

THE ELECTRIC LIGHT.

Formal Change of Name.—At a meeting of the board of directors of the Westinghouse Electric and Manufacturing Company on the 3d inst. a formal change in the name of the corporation from the Westinghouse Electric Company was made.

The Brush Electric Light Company, of Baltimore, Md., has received the contract from the municipal authorities of that city to light the streets and public buildings for a period of five years. The contract calls for 800 arc lights and 5,000 incandescent lamps. The Brush Company operates the Westinghouse alternating current arc and incandescent systems of electric lighting.

A Strange Collection.—The power of the electric light to attract a wide variety of insects has been put to use by the secretary of the electric light company at Stroudsburg, Pa., who has taken trouble for a year past to sort out various sorts of moths that have accumulated in the arc light globes night by night. The result has been a large collection of moths, some of them very rare and beautiful.

The Citizens Electric Lighting Company, of Braddock, Pa., has put a couple of Thomson-Houston arc light machines to work, and the light is proving very popular among the merchants, all of whom are having at least one 2,000 c. p. lamp placed in each of

their store doors. Hitherto gas light has been used for outside illumination in Braddock, and with the advent of electricity a noticeable improvement appears.

Anderson, S. C.—The recently installed plant at Anderson, S. C., is giving entire satisfaction. It is run in connection with the water works. A 500 light alternating dynamo of the National type and 50 h. p. Rice automatic engine make up the present plant. An additional dynamo will be installed this winter. Mr William C. Whitner, the engineer of this plant, is installing a similar one at Rock Hill, S. C., which will soon be completed.

The Charleston Light and Power Company, of Charleston, S. C., will, at an early date, move its works from its present cramped quarters to more capacious ones. The plant will be enlarged to a considerable extent, the steam plant to 1,000 h. p. The Corliss type of engines will be used and the electrical machinery will be of the Thomson-Houston system. The motor circuit installed during the past summer is giving satisfaction to both consumers and producers.

Removal of Offices.—Last week the Westinghouse Electric and Manufacturing Company removed from the offices in the Westinghouse building, which it had been occupying for several months, to the offices formerly used in the shop building, corner Garrison alley and Duquesne way, Pittsburgh. The removal was made with a twofold object in view, to serve the ends of economy and to secure greater conveniences in transacting business. The offices in the Westinghouse building were spacious and comfortable, the building being the finest structure of the kind in the city of Pittsburgh, but the one drawback of being isolated from the shop induced the management to decide upon the change which went into effect last week.

A Truly Rural Visitor.—A gentleman from the backwoods walked into Alexander, Barney & Chapin's store at 20 Cortlandt street, this city, the other day, and seeing the long rows of glassware, bottles, battery jars, etc., the many drawers, shelves and glass-covered cases, wanted to know whether he had fallen upon a grocery store or an establishment for the retailing of liquid refreshment. The new store continues to attract the attention of every passer-by. Incandescent lamps have been a "leader" during the past week, and the new "A. B. C." lamp is already meeting with much favor. This firm has also taken orders for a large number of Edison lamps, and at this early stage is calling on the factories for "more lamps, more lamps."

Immense Business of the Westinghouse Company.—The month of December promises to bring such a great amount of new business to the Westinghouse Electric Company that it will probably receive the credit of being the "red letter month" of the year. A large number of the older alternating current central station plants have made contracts with the company for an increase in their capacities, and among the new plants is one to be established at Kirksville, Mo., and another at Taylor, Tex. Each of these plants will have a capacity of 750 alternating current 16 c. p. incandescent lamps to start with, but it is expected that this will have to be increased at an early day. Including these two new stations, the Westinghouse alternating current system is now operated in more than 350 central station plants. The total capacity of these stations aggregates 700,000 lamps. This is a splendid record for any electric manufacturing company.

The Allegheny Light Company, of Pittsburgh, has heard some complaints from its patrons recently because of the fact that the light furnished has been a little variable. The company is now making changes about its station, to the end that coal may be used as fuel when necessary, the late trouble having been caused by inadequacy of the natural gas supply. This shortage of gas is said to be due, not to a diminution of the flow from the gas wells, but to the fact that consumption has been increasing with great rapidity. The Philadelphia Company, which has a monopoly of the natural gas business in and about Pittsburgh, is now seriously entertaining the idea of ceasing to furnish gas to furnaces. The gas so furnished cannot be metered, and the meter basis has been found very much more profitable than any contract arrangement. The Allegheny County Light Company, at any rate, intends to be ready to serve its patrons, be the gas supply ample or short.

APPLICATIONS OF POWER.

A Correction.—In our issue of Oct. 18 a news item referred to a tramway accident that occurred "on the Thomson-Houston line running between Fiesole and Florence" This statement is manifestly incorrect, as the Thomson-Houston has not now, and never has had, a line in Florence.

The street railway business of the Westinghouse Electric and Manufacturing Company is increasing in the same manner which has shown itself in the alternating current electric lighting work. The department is occupied day and night to its full capacity, and the motors are now expected to be turned out as rapidly as they are demanded. Springfield, Ill., is the last place at which a road was put in operation with the Westinghouse electric motor system, and everything started off with the greatest success.

Englewood, N. J.—Vigorous efforts are being made to secure for this beautiful suburban town an electric railway system, and several prominent citizens are active in pushing the matter. The proposed route is about three miles long, and would open up the fine ridges that lie just west of the Palisades, and are now unavailable on account of lack of convenient transportation. The road would unquestionably tend to build up the town, and greatly enhance the value of property. It is quite probable that an electric light plant may form an important part of the system, as Englewood, with its many fine residences, offers a capital opportunity for domestic lighting on a considerable scale.

PERSONALS.

Mr. C. D. Smith, of the National Carbon Company, is in Boston for ten days.

Mr. Thomas I. McLeod has just established himself as electrical and mechanical engineer at 91 Liberty street, this city.

Mr. Albert E. Rich, general manager of the Hunt Engineering Company, of Brooklyn, N. Y., was in Boston on business last week.

Mr. G. M. Mumford, of the C. & C. Motor Company, who has for some time been quite ill, has fully recovered and has again resumed his duties.

Mr. Edward Bell, auditor of the Western Union Telegraph Company, Chicago, will shortly have charge of the American District Telegraph System in that city.

Mr. J. G. White, formerly general manager of the Western Engineering Company, of Kearney, Neb., has opened an engineering office at 50 Broadway, in this city.

Mr. A. C. Durborow, business manager of the *Western Electrician*, was a successful democratic candidate for Congress in the third district of Illinois on Nov. 4.

Mr. F. S. Pearson, Chief Engineer of the steam and electrical departments of the West End Street Railway, has been confined to his home for a few days by a slight illness.

Captain C. F. Dunderdale, of Chicago, formerly representing the Westinghouse Electric Company, is now the consulting engineer of the Gray Current Motor Company of Elgin, Ill.

Mr. Herbert L. Webb, of the Metropolitan Telephone and Telegraph Company, delivers a lecture this week on "Submarine Telegraphy," at the Brooklyn Institute in Brooklyn, N. Y.

Mr. H. A. Douglas, assistant superintendent of the Chicago Telephone Company, and manager of the American District Telegraph and Burglar Alarm system, has resigned his position.

Mr. James Hamblet, president of the department of electricity of the Brooklyn Institute, delivered a lecture before the members and others last week on the "Electrical Transmission of Time."

Mr. M. Douglass Van Buren has been appointed constructing engineer for the Edison General Electric Company in the Central District, and will have his headquarters at the Chicago office of that company.

Mr. William S. Jones, of the Quaker City Electric Company, Philadelphia, was married to Miss Margaret Ella Alberts last week. The marriage took place in the Market Square Presbyterian Church, Germantown avenue.

Mr. Tom L. Johnson, well known as an enthusiastic advocate of electric street railways in Cleveland, O., was elected by the democrats of his State on Tuesday of last week as United States Congressman from Ohio.

Mr. D. C. Jackson, of this city, has been appointed district engineer of the Edison General Electric Company for the Central District to succeed Prof. F. B. Badt, who had resigned. Mr. Jackson's headquarters will be in the Rialto Building, Chicago.

Sir John Pender, prominently connected with English submarine cable enterprises, is one of a number of English parties who have brought suit to recover $250,000 from the Boston Heating Company. Sir John Pender's loss is said to have been $50,000.

Sibley College Lecturers.—Among the non-resident lecturers at Sibley College, Cornell University, the coming winter, will be Prof. S. P. Langley, Prof. Alexander Graham Bell, Prof W. A. Anthony, and possibly Prof. Elihu Thomson and Mr. Frank J. Sprague.

John T. Cowling, for a long time with the Excelsior Electric Company, but later superintendent for the Consumers' Gas Company, of Danville, Pa., has been appointed to the management of the Powellton Electric Company, a new concern, that has a franchise for lighting all of West Philadelphia.

Mr. A. T. Rowand has resigned his position as secretary of the Westinghouse Electric and Manufacturing Company, and Mr. Howard C. Levis has been elected to the office in his stead. Mr. Rowand retains his connection with the Union Switch and Signal Company, another of the Westinghouse interests. He is secretary of that company.

Mr. Emile Kolben, the chief engineer of the Schenectady works of the Edison General Electric Company, was recently presented with a beautiful white enameled lamp made in the style of his native country, Austria. The friends who were gathered at Mr. Kolben's home spent a very enjoyable evening, and toasts were drunk to Mr. Edison, Mr. Kruesi, Mr. Turner and others.

Mr. John X. Otis, formerly manager of the Edison Electric Light and Power Company, of Amsterdam, N. Y., has been compelled on account of his health to give up his work, and expects to spend considerable time in regaining his health. Before leaving Amsterdam Mr. Otis was presented with a gold headed cane by his subordinates in the electric light works, and with other reminders of friendship by a few of his Amsterdam friends.

Mr. C. H. Jackson has resigned from the position of vice-president of the Union Switch and Signal Company, of Pittsburgh, and his place has been filled by the election of Mr. E. H. Goodman to the vice-presidency. Mr. E. H. Goodman has been for some time the general manager of the Signal Company, and prior to his going with the Westinghouse people was well known as a prominent official of the Pullman Palace Car Company. The Signal Company has abandoned its Pittsburgh office, and will hereafter be represented only at the works, Swissvale, Pa.

MISCELLANEOUS NOTES.

Industrial Exhibition.—The department of State has been officially notified that an industrial exhibition will be held in Lyons, France, in 1892. There will be a special department of electricity, which will be open to exhibitors of all nations, and a cordial invitation is extended to Americans to exhibit and introduce their apparatus.

Medical Electricity.—A rather striking statement concerning the curative value of electricity comes to us from the other side of the water in the claim that the electric current has been successfully used for the extirpation of cancer. A current of 500 milliampères is completed locally through the diseased part, and it is said that a few applications suffice to check the malignant growth in a very remarkable manner. If this is true, it is certainly a most marvellous addition to our medical resources.

Edison Toy Company Meeting.—The annual meeting of the Edison Toy Manufacturing Company was held in Portland, Me., Oct. 30, at the office of Clarence Hale. Mr. Edison was represented by his secretary, Mr. Tate. The treasurer's report shows a capital stock of $1,000,000, and a working capital of $62,871.37. These officers were elected: Directors, Benjamin F. Stevens, Daniel Weld, J. W. Mackintosh, W. S. Hutchinson, T. A. Edison, Geo. Borgfeldt and O. E. Madden; clerk, Clarence Hale; treasurer and secretary, Daniel Weld.

The Jamaica Exhibition.—Extensive preparations are being made to insure the success of the International Exhibition to be held in Jamaica. As the centre of the British West India islands having an aggregate population of nearly a million, it is probable that an exhibition such as will be opened next January will attract very widespread attention, and that much will be done in the way of manufacturing exhibits to foster trade with the United States. Space for exhibitors is to be free, and all goods are admitted free of duty unless they are sold on the island. It seems likely that this is a good place for some of our enterprising electrical manufacturers to introduce their goods to what is so far, electrically, rather an undeveloped country. A. W. Preston, Boston, is the chairman of the New England committee for securing proper representation of New England manufactures.

Quotations on Electrical Stocks.—Messrs. F. Z. Maguire & Co, electrical securities, of 18 Wall street, this city, report the following quotations of Saturday, Nov. 8, from New York, Boston, and Washington and Nov. 7 from Pittsburgh:

NEW YORK.

	Bid.		Bid.
W. U. Tel. Co.	79⅛	Edison Gen. Elec. Co.	90
American Tele. & Cable	83	Edison Gen. Co. Def'd	82
Cent'l & So. Amer.	155	Consol'd Elec. Lt. Co.	
Mexican	208	Edison Ilin'g Co., N. Y.	67
Com. Cable Co.	101½	U. S. Elec. Lt. Co.	30
Postal Tel. Cable	39	North Am. Phon'gph.	35

BOSTON.

	Bid.		Bid.
Thomson-Houston	46	Ft. Wayne Co.	12½
" Pref'd.	27	Am. Bell	220
" Series C.	11½	Erie	43¾
" " D.	6⅛	New England	51½
" Int. Co.	....	Mexican	.77½
Thomson Welding Co.	185	Trop. American	....
Thomson Eu. Welding	....	Edison Phon'gph Doll.	2

WASHINGTON.

	Bid.		Bid.
Penna. Telephone	26	Eck. & Sold. Home Elec. Ry.	60
Ches. & Pot. Telephone	68¾	Georget'wn & Tenallyt'n.	48
Amer. Graphophone	13½		
U S. Electric Lt. (Wash.)	150		

PITTSBURGH.

	Bid.
Westinghouse Electric Manufacturing Company	26¼

Industrial and Trade Notes.

The Dale Manufacturing Company, 90 Fulton street, this city, is handling electric lamps, and can furnish these promptly on satisfactory terms. The company is also doing considerable business with the general electrical supply trade.

The New England Fire and Heat Regulator Company is a month behind its orders. This company has lately commenced to fit drying rooms in factories, the factory of the Tyer Rubber Company, at Andover, being one of the latest.

Central station managers will learn something to their interest by asking the Nubian Iron Enamel Company, of Chicago, to place their names on its mailing list, and by asking them how a saving can be effected by using Nubian enamel.

Vallee Bros. & Co., of Philadelphia, are handling the new compound for covering splices, which has been ordered by the board of underwriters of this city. It is said to be very superior to the old way of lapping joints, prevents corrosion and makes them thoroughly waterproof.

Locust Insulator Pins.—Mr. S. F. Chapman, of Asheville, N. C., carries a full line of locust screw insulator pins, standard size, 1⅛ and 1¼ inches stock, also cross-arms, and sells any specified amount desired, and can ship on telegraphic orders at any time from 1,000 to 100,000 pins to any place that may be designated.

The Standard Supply Company has been appointed New England agents for the Solar Carbon and Manufacturing Company, of Pittsburgh, and the Star Electrix Company, of Philadelphia. The Standard Company will manufacture and put on the market a new carbon battery called the "Hercules" for gas lighting and bell work.

The Gate City Electric Company, of Kansas City, which has recently increased its capital, has added to its large and complete stock of Okonite and Candee wires, and reports its volume of trade very rapidly increasing throughout the Southwest. One of the recent contracts taken is the 60-mile order for Candee aerial line wire for the Thomson-Houston Electric Company at Joplin, Mo.

Messrs. Stanley & Hall, 32-34 Frankfort street, this city, dealers in electrical house furnishings, have prepared a very useful article for distribution among their friends, which is at the same time a reminder of the business in which the firm is engaged. This is a little imitation ivory rule which, when folded, is three inches in length and of suitable size for carrying in the pocket.

The Baxter Electric Motor Company reports that it is rapidly completing the various sizes of its new design of motors suitable for all incandescent power circuit voltages, and the various sizes for the arc circuits are now ready for the market. Many strong features are claimed for these machines, and the company intends, if possible, to interest all prospective buyers, as it is confident of these features being appreciated.

John Simmons, 110 Centre street, New York, finding a demand for special fittings for electric street railway poles and brackets, has made up and carries in stock all the different styles and sizes necessary for a complete equipment such as is required for electric railway and electric light plants. Besides this special work, Mr. Simmons' concern does a general business in steam and gas fitting, and as engineers and plumbers.

The Western Electrical Supply Company, 310 North Third street, St. Louis, is in the market with an abundant stock of the standard supplies required by all electric light, power and railway companies, and is prepared to give prompt attention to all orders entrusted to its care. The company makes a specialty of the Grimshaw insulated wires, carrying a large quantity in stock, and is the agent for the C. & C. Electric Motor Company.

The Thomson-Houston Motor Company, of Boston, Mass., is sending out to the large manufacturers of New England a copy of a very neatly printed map of Boston and vicinity, and also a portion of the States of Massachusetts and Rhode Island. Accompanying the map are some valuable statistics. This souvenir is issued by the Thomson-Houston Motor Company to call especial attention to its system of electric power transmission.

The Hazeltine Electric Company, of St. Louis, Mo., has received from the Municipal Electric Light and Power Company, through Mr. James I. Ayer, its General Superintendent, an excellent letter of recommendation for a carbon protector which the Hazeltine Company is now placing upon the market. Mr. Ayer has given this protector a thorough test, and speaks in very high terms of it. A description of the protector will be found elsewhere in our columns this week.

Pierce Bros.' Trolley Wire Holder Company, of Leominster, is equipping the new Gloucester electric railway with its

new automatic overhead switch. This company has lately received orders to equip six different roads, and is making extensive additions to its factory in order to meet the rapidly increasing business. The Electric Merchandise Company, of Chicago; the Empire City Electric Company, New York, and T. C. White & Co., St. Louis, have recently been appointed agents for this company.

The Safety Insulated Wire and Cable Company is making a full line of flexible cords, all gauges, braided in silk, satin and cotton, and highly insulated with a seamless coat of rubber. It is claimed to be of a superior quality. The company recently received an order from one of the largest houses in the country for over 250,000 feet in assorted sizes. The underground wires and cables of the company still keep up their high reputation, and large orders are being received from all parts of the country.

The Eureka Tempered Copper Company, of North East, Pa., has received from Mr. Wm. M. Ramsay, assistant superintendent of the Federal Street & Pleasant Valley Passenger Railway Company, of Allegheny, Pa., a letter, in which he says: "In reply to your inquiry concerning our experience with tempered copper, would say that, after a year's use, we can heartily endorse it, and recommend it for all descriptions of bearings and for electrical purposes, such as commutator bars, trolley wheels, etc., etc."

The Star Electrix Company, recently incorporated, with Norman Marshall, late of the North American Construction Company, as president, and D. C. Spruance, late of the Westinghouse Company, as secretary and treasurer, has just increased its capital stock from $5,000 to $50,000. At present the company is manufacturing switches, gas attachments, insulating joints, cut-outs, sockets and incandescent electric supplies in general, most of which are covered by patents It is making a specialty of single and double pole switches and turning out over 500 per day.

C. B. Hanna & Co., St. Louis, Mo., who are dealers in a great variety of electric novelties, have been appointed agents of the Carpenter-Nevins Electro-Heating Company, of Minneapolis, Minn. They will carry a full line of the Carpenter-Nevins Company's goods, among which may be mentioned sad irons, polishing irons, hat irons, tailor's goose, soldering irons, embossing plates for book binders, pan-cake griddles, toasters, stew pans, tea and coffee pots, glue pots and heaters, baking ovens for domestic use, and heating apparatus for houses, stores, public buildings and street cars.

The Broadway Electric Company has lately opened a salesroom at 703 Broadway, New York, near Fourth street, and is carrying a full line of electrical novelties, specialties and supplies. The company is manufacturing an improved window tapper, made to illustrate and indicate any kind of specialty with an electric attachment similar to the hammer of an electric bell. In place of the hammer striking the bell, it is so arranged as to tap on the window, being suspended from the upper bar of a large store window sash, on two wires which conduct the current from the battery to the electromagnets. The manager is Mr. E. Strauss, and Mr. Wm. G. Spiegel is the electrician.

Mr. C. C. Foster, secretary and treasurer of the McCreary Electrical Specialty Company, will start next week on an extended trip along the Atlantic coast and through Alabama and Texas, and back through the Central States, stopping at the principal points en route. He will carry a full line of the company's specialties. The McCreary Company has added to its stock many excellent devices applicable to the incandescent lamp, particularly the cone reflectors, bulb reflectors, switches, flexible wire guard and also incandescent lamp guard for protecting lamps from dampness, dust, etc., and also for sustaining an incandescent lamp under water, guarding the socket from dampness. Their elegant new catalogue is out.

A Handsome Catalogue.—The C. & C. Electric Motor Company, whose factory is located at 402-404 Greenwich street, this city, has issued a nicely-printed and very neatly bound catalogue of the C. & C. motors and dynamos. Besides a carefully written description of the C. & C. motor, some interesting data concerning the company's standard motors may be found in the first part of the catalogue. The dynamos of this company, which are of the same general design as the standard motors, are also described and illustrated, and general directions given for setting up the C. & C. machines together with rules for their operation. The book also contains eight folded plates, each of which contains a fac simile letter from a prominent party who is using C. & C. motors or dynamos.

The Standard Underground Cable Company has issued a pamphlet of 24 pages, bound in a fancy illuminated cover, in which are given the opinions of Sir William Thomson, Prof. George Forbes, Dr. John Hopkinson and others on high tension underground circuits, together with the opinions of American authorities on the practicability of transmitting electricity by means of underground cables and endorsements of "Waring" insulation and "Waring" cables in general. Some strong testimonials are also given of the merits of the Standard underground telephone and telegraph cables, and also cables for a variety of other uses, and the last two pages of the pamphlet are given up to a history of gutta-percha and rubber insulated wires from the year 1846 to the present time.

The Electrical Supply Company, 171 Randolph street, Chicago, reports its business as constantly increasing, being especially large even for this season of the year. Many of the new articles for which this company has secured the agency are proving very salable, especially so in the case of the Habirshaw rubber covered wires. During the last year this house has found it necessary to increase the floor space and storage room to a very large extent, and even with the additional facilities is still far short of necessary space. The Electrical Supply Company has always endeavored to have a competent staff of office employés, and with its concise method of taking care of orders after they are received customers' wants are served promptly and to their best interests.

The A. W. Harris Oil Company, of Providence, R. I. makes a specialty of the manufacture of oils for both internal and external lubrication of all types of steam engines, also dynamo oil, which is claimed to be of superior quality. Having made the subject of lubrication a study for many years, and also having the advantage of a practical knowledge of the construction of steam machinery, the productions of this company would seem to be worthy the consideration of all users of steam power. These oils have attained a very high reputation, and are used in every State in the Union, also in foreign countries. Among the prominent steam engine builders who have adopted and recommended these oils are the E. P. Allis Company, Milwaukee, Wis., Providence Steam Engine Company, Wm. A. Harris Steam Engine Company, Providence, R. I., and the Putnam Machine Company, Fitchburg, Mass.

Mr. A. L. Bogart, manufacturer and electrician, 22 Union Square, New York, manufacturer of electric supplies, electric bells, burglar alarms, annunciators, batteries, etc., is the inventor and sole owner of patents covering a full line of improved electric gas lighting apparatus, and the celebrated Bartholdi automatic gas light burner. Mr. Bogart some time since brought suit in the Philadelphia courts against the people mentioned in the following note: "In the suits of A. L. Bogart, of New York, vs. H. A. Cleverly and H. Pinkham, of Philadelphia, for infringement of the Packard patent. On application of the complainant, Judge Butler, of the United States Circuit Court of the District of Pennsylvania, on Oct. 28 granted injunctions against both defendants, restraining them from the further manufacture of ratchet pendant electric gas lighting burners."

The Electric Safety Engine Stop Company, of Boston, has an invention for the instantaneous stopping of engines in factories. The "stop" is attached to the engine, near the throttle valve, or to the automatic cut-off, and is electrically connected with the various rooms in a factory—where electric push buttons are placed at convenient distances, or before each workman, if desired—enabling any one, in case of an accident, to press the button, and, almost instantly, shut off power and stop the work, without the slightest injury either to engine or machinery. The usual method to stop the engine when urgency calls for it is to signal the engineer by means of the speaking tube or electric bell; but much valuable time is lost in the endeavor to reach those places during the confusion of an accident, and as the engineer cannot at all times be near the engine, with his hands on the throttle awaiting a call, more serious delays are occasioned.

The Chalmers-Spence Company's Exhibit.—One of the most attractive exhibits at the American Institute Fair this year is that of the Chalmers-Spence Company, 59-61 Liberty Street, New York, which shows a full line of its standard asbestos specialties. The booth is admirably located, being in the centre aisle of the Fair, just as one enters Machinery Hall. The visitor invariably finds a few moments to stop in wonder at the piece of asbestos exhibited suspended in a flaming gas jet, which so clearly illustrates its wonderful fire-proof qualities. A machine in operation making asbestos wicking, under the guidance of an operator, also comes in for its share of attention. The company's famous fire-felt pipe and boiler coverings are also shown, as well as the asbestos packings, cements, sheathing and patent superior covering. The roof of the booth is covered with patent superator. This material is meeting with much favor for fire-proofing the walls and ceilings of dry-rooms, engine and boiler rooms, etc. Taken altogether the exhibit, a very creditable one, is of great interest to the many who visit the Fair daily, and no doubt one of profit to the Chalmers-Spence Company.

The Electrical Construction and Repair Company, of 205-207 Canal street, Chicago, will do general construction work, giving special attention to street railway construction. Several employés of the Sprague Electric Equipment Company have been retained for this department, and will be under the immediate charge of W. Sharpe. The company promises to do good work and to use none but the most modern methods of construction. Mr. C. M. Barclay, who represented the Sprague Electric Railway and Motor Company for several years in Chicago and the West, and was also secretary for the Sprague Electric Equipment Company, will be the general manager; Mr. W. A. Kreider, whose mechanical knowledge will be of great service to the company, will act as secretary. Recognizing the difficulty street railway companies encounter in having repairs done in a prompt manner and at a reasonable cost, this firm has equipped a repair department, where armatures and field coils of any system will be rewound or repaired. The repair department will be under the management of Mr. J. G. Hart, who has had many years experience.

J. G. White & Co. is the name of a new firm just opening an office at 50 Broadway, this city, to do a general business as electrical engineers and contractors. Mr. White was formerly the general manager of the Western Engineering Company, of Kearney, Neb., but has disposed of all his interest in that concern, and will now give his entire attention to the prompt and careful consideration of all engineering or business problems that may be submitted to the new firm. Among the installations of the Western Engineering Company over the construction of which Mr. White exercised supervision may be mentioned the railway plants at Omaha, Neb.; St. Jo, Mo.; Salt Lake City, Utah; Nashville, Tenn.; Sioux Falls, So. Dak., and Sherman, Tex., as well as electric light plants at Lincoln, Kearney and Fremont, Neb., and Council Bluffs, Ia. Mr. White will have the assistance in his new work of some of the best talent in the country, both from men eminent in scientific circles and from others who have been very successful in the commercial branch of the electrical business. He will make a specialty of electric railway work, and is prepared to furnish complete equipments for electric roads, including steam plants, electric power plants, line and car equipments, including motors made by any of the prominent manufacturers. In engineering work the new firm will aim to serve its employers with honesty, energy, and to the best of its ability, and in contract work will endeavor to do efficient and durable work.

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Phonograph Motor.—I noticed in the motors used for driving Edison phonographs that the brushes, instead of being set 180 degrees apart, are only about 100 degrees apart. What is the reason for this? There seems to be no sparking, and the motor runs efficiently. C. H. W.

The motor is a four pole machine and the armature is cross-connected so that only two brushes are required, and these, as in every similar machine, are placed 90 degrees apart. This construction is used to secure low speed combined with efficiency. It is the ordinary arrangement of four-pole dynamos and motors.

Electro-Plating.—Can I use a dynamo, ordinarily employed for incandescent lighting, for nickel plating, when not otherwise in use? If not, why? J. G. M.

It is not easy to use an incandescent dynamo in the way you mention, for the reason that nickel plating requires a very low voltage—not in excess of five volts, even when starting the deposit. You cannot readily cut down the voltage of an incandescent machine to such a point and use it economically; nor is it advisable to run many deposit vats in series. Under the circumstances mentioned a storage battery is, by all odds, the best method of getting a current for electro-plating. The cells can be charged in series and discharged in parallel on the deposit vats with excellent effect.

Arc Lighting.—Can you give me information on the following points: (1) I wish to build a dynamo which at first will run at 10 or 12 arc lamps of 2,000 candle power, 10 ampères, with an ultimate capacity of 30. The circuit is to be one and one-half miles long. What size of wire should I use? (2) Is it more difficult to run 20 arc lamps in series than one or two—as regards steadiness of light A. H.

(1) No. 6 is about the usual size of wire for 2,000 candle power arc lamps; though by forcing the potential a little, 7 or 8 might do. (2) If an arc dynamo is supplied with a proper regulator for constant current, 20 arc lamps can be run in series with practically the same facility as one or two. An automatic regulator is, however, an absolute necessity to secure good results.

Trouble with a Dynamo.—Can you give me any idea as to what is the probable trouble with a little dynamo I have made? It doesn't generate any current, although it will run as a motor with four one-quart Bunsen cells. Running it as a dynamo there is no result. The armature is two and a half inches in diameter and two inches long, has 12 segments and is wound with No. 20 wire. SUBSCRIBER.

It is generally impossible to tell what is the difficulty that afflicts a given dynamo without seeing and investigating the machine, and then it is not altogether easy. On general principles, however, we advise you to look for a ground in the armature. See if there is not connection between wires where they cross over the head of the armature, or between some of these and the core, or between the commutator and the shaft. You had better see if you get any current between the poles of your dynamo when they are connected through an ammeter. It may be that being a series machine it doesn't excite readily owing to mechanical imperfection in the magnet or to great resistance. We can only give these hints, because we have not seen the machine, and therefore, as a rule, would not attempt to answer the question at all.

Winding Armature.—Will you please give me answers to the following questions: In winding the armature of a dynamo, described in *Scientific American Supplement*, No. 600, would not the last coil be longer than the first? What sized wire is best suited for an armature to have a given output of 12 ampères? In what direction does the current flow from the dynamo—that corresponding to the direction of rotation of the armature, or the opposite one? W. H. J.

(1) We regret to say that so many questions have come in concerning the *Scientific American* dynamo that we have been obliged to draw the line at that machine. The *Scientific American* is the proper place to which to refer inquiries on this subject. (2) In any ordinary form of armature one has the advantage of two sides of the armature placed in parallel. Bearing this in mind, and noting that there is an excellent chance for cooling in armature wire, it is evident that a rather high currrent density can be allowed. No. 15 would probably serve your purpose. (3) There is no general rule. Practice differs with different arrangements in the machine. The direction depends both on the direction of revolution of the armature and the direction in which the field magnets are magnetized.

Coupling Compound Dynamos.—Will you be kind enough to inform me whether it would be practicable to couple two compound wound machines of the same capacity, run by separate engines, together in multiple; for example, two Wenstrom incandescent machines? If it can be done, is it necessary to connect a rheostat in the field circuit of each machine? Please state the best method of connection. J. H. J.

It is not always easy to arrange two compound wound dynamos to run in multiple arc, there being a certain tendency to instability when this is attempted, so that the work will be unevenly divided between the two machines and they will tend to react upon each other. The best method of accomplishing such coupling would be to connect directly across between the positive brushes of the two machines so that not only the shunt coils are in parallel circuit, but the series coils also. In this way not only is there direct connection between the series coils of the two machines through the common line which they feed, but also a connection from brush to brush. Under these circumstances the machines will work together quite satisfactorily, provided the voltage is kept very nearly the same in each machine. The power of mutual adjustment between the two is sufficient, however, to allow driving them from separate engines, provided these are similar in their quickness of governing. It is better to have a rheostat in the shunt circuit of each machine, unless the voltages are already practically identical.

Commutating Direct Currents.—Will you kindly inform me through the columns of THE ELECTRICAL WORLD concerning the following points: I premise by stating that I wish to construct an apparatus for medical purposes, as cautery, electrolysis, etc. (1) Can a small toy motor, such as is sold from $3 to $5, be run with the Edison 110-volt current, a low power lamp being interposed as resistance? Very little power is required, but high speed. (2) How much resistance should I have in circuit to maintain the intensity of two ampères, the electromotive force being 110 volts? Which is the better for the purpose, one large lamp or a number of small ones; and, if the latter, should they be arranged in series or in parallel? (3) I wish to construct a converter to form something like an ordinary induction coil. What should be the length and size of wire for primary coil to carry two ampères current, and what should be the secondary wire to give induced currents approximately as follows: (1) six volts and 32 ampères; (2) three volts and 16 ampères; (3) 55 volts and about 50 milliampères? (4) Would a different form of converter or a different arrangement give better results? It should be understood that these three currents are intended, respectively, for cautery, electrolysis and therapeutic effects. (5) After completing the coil, would an extraordinary winding of soft iron wire give any advantage? G. A. H.

(1) Yes. (2) Solved by Ohm's law $C = \frac{E}{R}$. In using lamps for resistance in running your motor, perhaps the best way would be to put two 20 c. p. lamps in parallel with each other and in series with the motor. They should be of voltage a volt or two less than the normal pressure of the circuit, so as to work little above normal candle power. (3) We really would not advise you to attempt making the multiplex converter you describe. You can get the combinations of current you require by a much easier process. For example, for cautery you appear to want about 30 ampères as a maximum. This you can get by interposing about 3 ohms resistance directly in your Edison circuit. Such a resistance can very well be made of coarse German silver wire wound into an open spiral so that the turns will keep apart. Clamping a terminal at various points of this spiral will soon give you just the current you require. The wire should be coarse and uninsulated, and a spiral may best be strung in a frame so as to keep it taut and allow free circulation of air. Thirteen volts and 16 ampères will be given by a little over six ohms interposed in the same way. Currents as low as 50 milliampères can best be gotten from a battery on an ordinary medical coil. We think that this arrangement would be cheaper, simpler, and more satisfactory than any induction coil method operated on the same circuit. You can very well use the Edison current instead of the battery if you want to, by interposing a single lamp as resistance and connecting it in series with a primary of a common medical induction coil, in case you do not want to use a battery. The commutation of a continuous current is not an easy thing to accomplish without very troublesome sparking, and we would not recommend it so long as a simpler method is available. (4) Yes; we think you can utilize the current direct better than through the medium of commutation and transformer. (5) An extraordinary iron case should not be required in an induction coil.

Business Notices.

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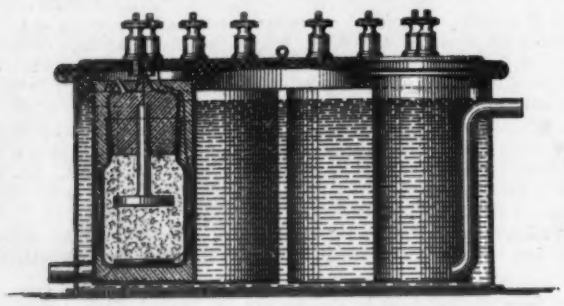
OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS

U. S. PATENTS ISSUED NOV. 4, 1890.

439,662. Electric Railway; Rudolph M. Hunter, of Philadelphia, Assignor to the Electric Car Company of America, of same place. Application filed Sept. 23, 1886. Divided and this application filed June 1, 1887. In an electric railway, the combination of a suspended bared working conductor supported from above, a supply conductor connected to the working conductor at intervals along the track, a source of electric energy to supply electricity to the supply conductor, a traveling vehicle, tracks for said vehicle parallel to said working conductor, an electric motor on said vehicle, and a traveling collector moved by said vehicle and making contact with said suspended conductor.

439,724. Electric Heater; Charles W. Drew and Edward R. Francis, of Minneapolis, Minn. Application filed Feb. 20, 1890. The combination, in an electric heater with a suitable casing, of an electric insulating and non-heat-conducting base, electrical resistance consisting of rods or strips of carbon, graphite or graphitized material, a series of blocks of electric conducting material provided with perforations, into which the ends of said rods or strips are inserted, and rods secured to said base upon which said blocks are independently movable, so as to allow for the expansion or contraction of said rods independently.

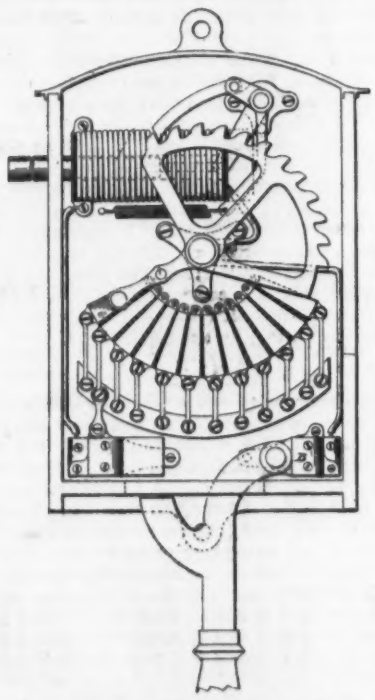


No. 439,737.—STANDARD GALVANIC CELL.

439,737. Standard Galvanic Cell; Edward Weston, of Newark, N. J., Application filed May 12, 1890. The combination of an inclosing vessel, a series of galvanic cells supported therein, and means for uniformly and simultaneously varying the temperature of said cells.

439,746. Trolley Line Switch for Overhead Electrical Conductors; William Le Roy Emmet, of East Rockaway, N. Y. Application filed May 7, 1890. This invention involves a switch for an overhead electrical conductor where two wires converge into one, said switch having one side consisting of a continuous flange connecting two wires, also having an interrupted flange higher than said continuous flange, one end of which interrupted flange is connected to a third wire and separated from said continuous flange by a score of such depth and width as will act as a sufficient guide for the flange of the trolley, and a second score on the other side of the interrupted flange, the far side of said score being formed by any suitable flange or ear, said second score being of such depth that when one flange of a trolley is passing through it the other flange will be carried clear of the continuous flange.

439,775. Electric Motor and Generator; Alfred Gartner, of Newark, N. J., Assignor by mesne assignments to Alfred A. Schmidt, of same place. Application filed Aug. 16, 1889. In an electric motor the combination of an insulating, sliding and regulating bar, two metallic springs on the lower end of said bar and



No. 439,859.—MAGAZINE FUSE-BOX.

arranged opposite each other, a pin connecting said springs, two stationary insulating bars arranged alternately opposite the sliding bar, and a series of springs secured to said stationary bars, each of said springs being connected with the coils of the magnets, said combination of parts being adapted to increase or diminish the magnetic force.

439,850. Secondary Battery Plate; Albert E. Woolf, of New York, N. Y. Application filed Feb. 13, 1890. An electrode comprising a support folded upon itself in a zigzag form, each fold whereof extends entirely across the electrode, and having its greatest width crosswise of the electrode, active material placed between the folds of the support, and a sustaining band or clasp at the edge of the electrode.

439,859. Magazine Fuse-Box for Electric Circuits; William F. Bossert, of Ilion, N. Y. Application filed July 30, 1890. The invention consists of a series of fuse-strips in combination with an arm adapted to move step by step, and an electro-magnet or solenoid arranged to move said arm through a segmental rack, and pawl one step each time it is energized. The main current is shunted into the magnet or solenoid whenever the fuse through which the current is flowing is destroyed.

439,867. Electric Railway; Mark M. Dewey, of Syracuse, N. Y., Assignor to the Dewey Corporation, of same place. Application filed June 30, 1890. In an electric railway, a source of irregular or alternating currents, a line-working conductor extending therefrom, a series of coils distributed apart along the way and connected with the conductor in series, a vehicle, a motor to propel said vehicle, electric connections between said motor and working conductor, and means carried by the vehicle to cause the generation of counter electromotive force in one or more of the said coils near the vehicle.

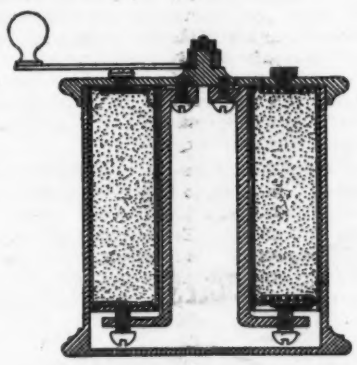
439,904. Electric Arc Lamp; Harold C. Shubert, of Chicago, Ill., Assignor to the Western Electric Company, of same place. Application filed Aug. 30, 1890. In an electric arc lamp, the combination, with the carbon-holder, of a spring bearing on one side thereof, and a pivoted feed dog upon the other side thereof, the said dog having a knife edge whereby the holder is positively fed.

439,906. Automatic Car Register; William B. Sprague and Charles W. Kellogg, of Chicago, Ill. Application filed June 20, 1890. In an automatic register, the combination of an electric circuit, a receiver, two conductors arranged at a given point in the circuit but separated to leave a break therein, a circuit closing device carried by a moving object having a surface made up of alternate conducting and non-conducting portions adapted to be brought in contact with said conductors and thereby alternately make and break the circuit during predetermined intervals, two conductors also arranged in the circuit near said point and insulated from each other, one of which also has a surface made up of alternating conducting and non-conducting portions, and a circuit closer carried by the said moving object adapted to connect last two conductors, producing by its passage over the same a second series of makes and breaks in the circuit, also during predetermined intervals.

439,916. Device for Applying a Coating to Electric Conductors; James Thomas Whittlesey, of Lynn, Mass. Application filed Dec. 20, 1889. The combination, with an electric car, of an apparatus moving therewith for applying a coating of moisture-repellent substance to the electric conductor, comprising a mechanically operated self-feeding device adapted to move in contact with the conductor.

439,929. Method of and Apparatus for Connecting Dynamos; Charles T. Child, of Brooklyn, N. Y. Application filed March 19, 1890. A method of connecting compound-wound dynamo machines in multiple arc with the working circuit, which consists in simultaneously making or breaking the positive, neutral and negative circuits leading from the dynamo.

439,939. Rheostat; Edwin Randolph Gilbert, of Hartford, Conn. Application filed Aug. 21, 1890. An electrical resistance



No. 439,939.—RHEOSTAT.

composition consisting in a mixture of powdered metal and magnesium carbonate.

439,941. Street or Station Indicator; Louis Goldstone, of San Francisco, Cal. Application filed Jan. 20, 1890. In a street and station indicator, the combination of a card-bearing shaft, means for rotating the same, a studded wheel upon a second shaft, a pinion adjacent thereto and turning therewith a cog-wheel on the card-bearing shaft, with which the pinion meshes, a pivoted armature provided with inwardly extending studs adapted to be engaged alternately by the outwardly projecting pins of the studded wheel, magnets arranged in front of the armature and having their poles facing the same so as to abnormally contact therewith, a spring for returning the armature to its normal position, a set screw or adjustable stop for the armature, and electrical connection with the magnets for alternately disengaging and bringing into engagement the armature and magnets, whereby the shaft is allowed to partly rotate.

439,959. Telegraph Key; William A. J. Kohrn, of San Francisco, Cal. Application filed May 10, 1890. The combination, with a telegraph key, of a circuit-closing lever pivoted to the key base and provided with a curved finger adapted to force the contact point of the key lever into contact with the anvil point.

439,974. Electrical Generator; Frederick L. McGahan, of Indianapolis, Ind. Application filed Sept. 8, 1890. In an electrical generator, an armature composed of a hub mounted on a hollow axle, hollow spokes connected to such hub and tapping the opening in such axle, brackets connected to the outer ends of said spokes, housings between the brackets, secured together by a bolt, and a series of bobbins arranged in pairs between such spokes, composed of a frame with triple coils of wire wound thereon, overlapping each other at angles.

440,013. Electric Indicator; Leston O. Chatfield, of Benton Harbor, Mich. Application filed Dec. 12, 1889. In an electric circuit breaker the combination of an inclined way having two series of insulated metallic strips or contacts, the strips of both series being in contact with metallic pieces, adapted to form circuit connections, a gravity operated circuit closer, an arm pivoted to one side of the way to retain the circuit-closer, and an electro-magnet adapted to vibrate said arm to release said circuit-closer.

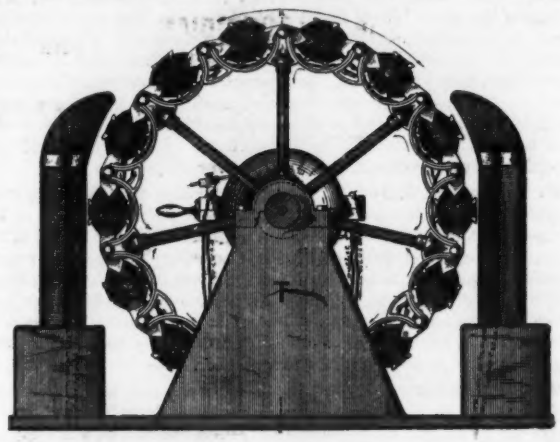
440,016. Automatic Regulator for Dynamos and Motors; Fremont J. Cleaver and George Fassold, of Pittsburgh, Pa. Application filed April 11, 1890. In a regulator for dynamos and motors, the combination of an amature formed of a hollow cylinder of non-magnetic material, conductors arranged upon the hollow cylinder, a commutator cylinder connected with the conductors, a movable armature cylinder, and commutator-brushes connected with the armature-core.

440,023. Electrode for Secondary Batteries; Justus B. Entz, of New York, and William A. Phillips, of Schenectady, N. Y., Assignors to the Waddell-Entz Electric Company, of New York, N. Y. Application filed Feb. 20, 1890. A support or frame for the active material of a battery, consisting of a net-work of wire in the form of a cylinder or tube.

440,024. Method of Making Electrodes for Secondary Batteries; Justus B. Entz, of New York, and William B. Phillips, of Brooklyn, Assignors to the Waddell-Entz Electric Company, of New York, N. Y. Application filed July 12, 1890. The invention consists in combining with oxide of copper a small portion of sulphur and then heating the mixture. The sulphur is thoroughly mixed with the oxide and then applied to the support, which in this instance is a woven copper wire structure. The whole thing is then heated to burn off the sulphur.

440,042. Insulator for Electric Conductors; William Kessler, of Lafayette, Ind. Application filed Aug. 8, 1890. The invention comprises an insulator composed of two cylindrical sections adapted to be rigidly joined together. The abutting faces of the sections are provided with grooves which coincide to form a cylindrical opening for a wire.

440,070. Magneto-Separator for Grain; Ewald Von Syo, of Augsburg, Germany, Assignor to Phillip Adam Tafel. Application filed May 14, 1890. The apparatus for separating magnetic particles or impurities from grain or other granular or pulverized materials, consisting of the combination of one or more rotating inclined drums, in the face of which the free poles or sides of permanent or electromagnets are arranged in the form of a ring or rings, and an inclined channel arranged to receive within apertures in its bottom the said magnet drum or drums in such a manner that the face of the rotating magnet drum or drums, the



No. 439,974.—ELECTRICAL GENERATOR.

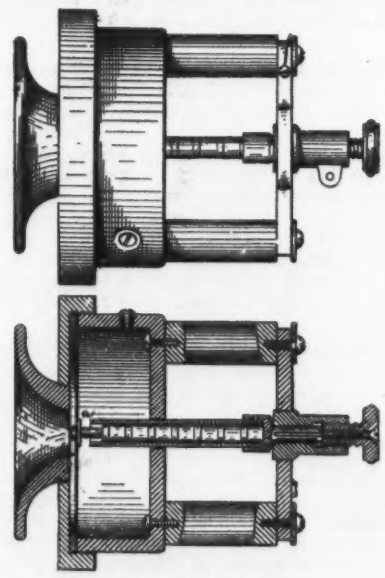
free poles or actual sides of the magnets, and the bottom of the conducting channel will form a continuous inclined plane.

440,071. Electric Heater; Charles H. Talmage, of Kansas City, Mo. Application filed Nov. 3, 1889. An electric heater consisting of a transformer having a primary coil and a closed secondary circuit of sheet-metal cylinders surrounding the primary coil whereby a current of electricity of moderately high electromotive force can be transformed into a heating current.

440,091. Holder for Telephone Receivers; Frank Tiffin Tinning and William Kerr Sumner Tinning, of Toronto, Can., Assignors of one-fifth to Charles Warren Irwin, of same place. Application filed April 21, 1889. The invention consists of securing to the wall at a convenient distance from a telephone a bracket, through the end of which is fitted an extension-arm provided with fingers designed to hold the receiver, the said extension arm being so held in the bracket as to allow of its being vertically and longitudinally adjusted.

440,096. Telephone; Sigmund Bergmann, of New York, N. Y. Application filed Feb. 28, 1884. A thermal telephone comprising the combination of a vibrating sound-reproducing body, two or more electrodes sensitive to heat making end contact with each other, and a tube inclosing said electrodes and supporting them in proximity to the vibrating body, whereby the expansion and contraction of said electrodes move the sound-reproducing body.

440,106. Adjustable Trolley and Guard for Electric Wires; Lewis S. Hoyt, of Boston, Mass. Application filed June 25, 1890. The invention comprises a journal-frame provided with slotted socket to permit a semi-diameter revolution or less around the supporting trolley pole, right and left pairs of inclosing discs, the outer of which are provided with lugs to form



No. 440,096.—TELEPHONE.

a parallel support against said journal-frame, and the spiral springs therein, which comprise the guard.

440,115. Electrical Burglar Alarm; Francis Pierce, of Philadelphia, Pa., Assignor of one-half to William J. Phillips, of same place. Application filed May 8, 1889. In an electric burglar alarm, the combination, with the main line having a weak battery, of the branch wires of approximately equal resistances connected to electromagnets, the armature wheel disposed between the said magnets and provided with a pawl-and-rachet mechanism to normally hold the armature out of contact with the magnets, and the strong battery adapted to be connected to the main line to actuate the armature-wheel.

440,118. Automatic Toll System for Telephone Pay Stations; Howard C. Root, of Brooklyn, N. Y. Application filed May 20, 1890. In an automatic toll-box for telephone pay stations, the combination of an inclined chute with a number of movable fingers having points arranged at different distances from the bottom of the same chute, and connections whereby coins passing through the same chute will transmit different signals to the operator at the exchange.

Copies of the specifications and drawings complete of any of the patents mentioned in this record—or of any other patents issued since 1886—can be had for 25 cents. Give the date and number of patent desired, and address The W. J. Johnston Co., Ltd., Times Building, N. Y.